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J. F. KELLY, *Editor*

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EDITORIALS

A NEW THOUGHT

To The Editor,
Iron & Steel Engineer,
Pittsburgh, Pa.:

Your editorial in your September issue was a most effective presentation of the trend of the times in the Iron and Steel Industry.

Your breakdown, starting with the Blast Furnace, then the Open Hearth and finally ending with Finishing Mills was a technical treat and is, no doubt, basically sound.

It occurs to me, however, that the General Managers, the Operating Superintendents and the Engineers of our great Industry are being loaded to the saturation point, to produce more and more for less and less.

The operating personnel has shoulders wide and broad and are ever ready to accept new responsibilities as well as discharge their old ones, however, did it ever occur to you that the science of marketing and distribution might offer the same advantages for development in assisting the Steel Industry to deliver their product at less dollars per ton to the ultimate consumer.

For example, a Steel Plant may be able to place sheets in Detroit at less dollars per ton than its immediate neighbor, due supposedly to lower first costs but in reality, due to the fact that their marketing and distribution facilities are superior.

Might it not be wise for our Industry to open up these apparent virgin avenues and elevate the science of marketing and distribution to the same degree enjoyed by those executives and engineers who have made production the art it is today?

The thought that I am endeavoring to convey is that more and more for less and less cannot forever come out of the lap of production, but marketing and distribution must contribute its tithe.

Yours truly,

A CONSTANT READER.

STANDARD METHOD OF COMPARING FUEL EFFICIENCY RECORDS

The following suggestion has been submitted by three of our active members of the Combustion Engineering Division as a program for this Division. To our mind this is a very valuable suggestion. May we kindly ask that you review this suggestion and advise us whether you feel we should adopt it and make it a part of our Combustion Engineering Division's program?

"In replying to your letter of September 30, relative to suggestions for the Combustion Engineering Division of the Association of Iron & Steel Electrical Engineers, would say that I have discussed this with a number of engineers and we feel that one of the most valuable contributions of the Association would be the submission of a standard method of comparing fuel efficiency records, both for heating furnaces as well as boilers.

"In explanation would say that we have found in our visits to other plants and in discussion of fuel matters in the several meetings that there is a considerable difference in methods of reporting efficiencies and in factors; i. e., pounds of coal, gross B.T.U., net B. T. U., efficiencies for short periods or monthly efficiencies, gross or net with various methods of arriving at auxiliary steam allowances, units of cost values; i. e., B.H.P. month or cost per 1,000 pounds of steam, etc., which make comparisons difficult.

"Naturally each plant thinks their own method is most satisfactory and it would be difficult to change methods of accounting but if a suitable questionnaire were sent out to all plants it would be possible to find out what methods were generally used and possibly a standard form suggested which could be incorporated in the present records for comparison with other plants by those in a position to obtain the figures.

"You will realize that we believe we have at some of our plants very efficient units, but we do not have any way of finding out whether we are as good or better than similar plants of other companies, and we have heard of results at other plants which are apparently so good as to be worth investigation, but we have not sufficient data as to the method used in calculating efficiencies and as a result we question them.

"While this subject is difficult to handle, I believe that a committee of fuel and steam engineers of the Iron and Steel Industry could obtain by a questionnaire sufficient data to determine the probable value of such a standard."

The Steel Industry's advice and opinions on the suggestion is invited by the Combustion Engineering Division of the A. I. & S. E. E.

NEW ELECTRICAL DEVELOPMENTS

"The Use of Photo-Electric Relays as a Limit Switch on Shear Tables, Gauging Tables, Pipe Sizing Machines, Pipe Drifting Machines, Pickling Machines and on Finishing Mills" will be of interest to electrical engineers and rolling mill superintendents in a paper to be presented at Pittsburgh, October 24, 1931, in the Blue Room of the William Penn Hotel at 7:30 P. M. The control of close speed adjustments by motor field using the thyratron vacuum tube is a large field that has hardly been touched and as one feature a demonstration will be given for automatic screwdown application at the Pittsburgh meeting.

"The Application of Non-radio Vacuum Tubes in the Steel Industry" will be the subject of a paper to be presented before the Philadelphia District Section on October 31, 1931, at the Engineers Club at 6:30 P. M. The author of this paper will describe the contemplated application of non-radio tubes in the Steel Industry. He will describe the use of tubes as Flag or Limit switches; also the use of tubes for recording the density of gases or fluids, including the smoke recorder. The author will also present a discussion on the daylight relay and its application on turning on and off the shop lights, depending on the intensity of the sunlight. There will also be an interesting discussion on the "Starting and Speed Control of Direct Current Motors from an Alternating Current Supply Through Tube Control."

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The Manufacture of Acid Electric Steel and Cast Iron†

By H. H. WALTHER*

During the past decade the electric furnace has attained an enviable position in the field of quality steels and cast irons. The metallurgical reactions occurring during the melting, oxidizing and deoxidizing stages are so familiar that any reference to them would merely be a repetition of well known facts. In this paper the writer will limit himself to a discussion of the practical features involved in the successful economical operation of the electric furnace.

The plant with which the speaker is connected operates two, 3-ton per hour capacity, direct arc, three phase, electric furnaces of a well known make. These furnaces have replaced two earlier type electric furnaces of another make, and a 2-ton Bessemer. The first of our present furnaces was installed in May 1923, and the second in February 1927.

Our production is limited almost exclusively, to two products, steel wheels and alloy cast iron brake drums for trucks and busses. The steel wheels are of hollow spoke construction, having a metal thickness of 3/16 to 3/8 inch, and vary in weight from 35 to 600 pounds. To successfully run such a thin section, the metal must be very hot. Our pouring temperature for steel is 3250° F., at least 200° F. hotter than the average steel pouring temperature. The alloy cast iron is refined at 2950°-3000° F. which also is several hundred degrees hotter than the usual procedure. Later in the paper the author will include operating data and costs. When comparing these figures bear in mind the unusual temperature conditions encountered with our practice.

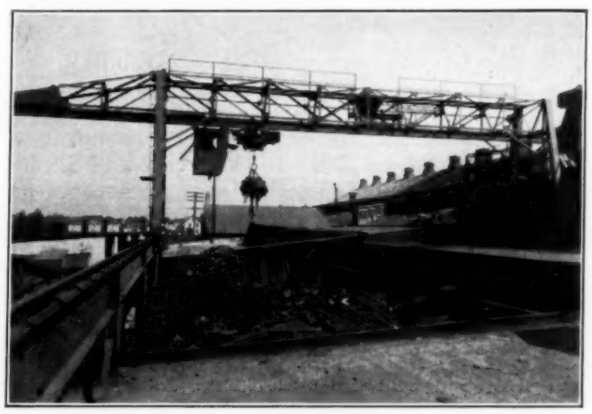


FIG. 1.

Furnace Melting Record for Steel

In Table No. 1 are included the melting records for a typical year's operation of one electric furnace on steel heats alone. It illustrates the consistent results easily obtainable on straight production work during normal business conditions.

TABLE NO. 1

	Net Tons Per Month	K.W.H. Per Net Ton	Time Per Net Ton In Hours	3 Months Average Net Tons Per Roof	3 Months Average Net Tons Per Sidewall
	700	500	.333	1200	1800
January	730	482	.329		
February	821	483	.323		
March	748	497	.328	700	1000
April	776	488	.319		
May	813	482	.316		
June	807	486	.331	700	1275
July	808	487	.322		
August	809	489	.321		
September	820	500	.325	650	1225
October	810	481	.306		
November	525	483	.322		
December	660	496	.348	675	1100
Yearly Average	761	488	.324	680	1150
		(1 Hr. 54 Min./Ht.)			

	ELECTRODES			
	Pounds Carbon Per Net Ton	Pounds Graphite Per Net Ton	Charge Per Heat In Net Tons	Time Power Off to Power on between Heats Minutes Per Ton Charged
	12	6	4.5	2
January		3.09	5.98	1.3
February		3.23	6.03	1.3
March		4.46	6.09	1.5
April		4.47	5.74	1.4
May		5.34	5.60	1.5
June		5.39	5.76	1.5
July		5.24	6.08	1.4
August		4.80	5.95	1.3
September		4.73	5.61	1.3
October		4.25	5.95	1.1
November		4.62	5.70	1.3
December		4.18	5.74	1.2
		4.48	5.85	1.34
		(7.8 Min./Ht.)		

Perhaps the item that first attracts attention is the short interval between heats. From the table we see the charging time for the average heat of 5.8 tons is only 7.8 minutes. This short time is obtained by team work, the charging gang acting as a unit.

The writer believes a brief description of our charging practice will be interesting. An electric magnet suspended from a yard crane, transfers the raw scrap from the yard to an inclined chute (Fig. 1). The furnace charging pans are transferred to buggies and shoved under the chute. A little prying of the scrap on the chute, assisted when necessary by an electric winch allows the scrap to fall and quickly fill the pan (Fig. 2). The buggy is then pushed over the scales and the weight of the scrap chalked upon the pan. The latter is then removed

† Presented at A. I. & S. E. E. Electric Heating and Welding Conference, Pittsburgh, Pa., January 21, 1931.

* Director of Research at the Dayton Steel Foundry, Dayton, Ohio.

from the buggy by a crane and transferred to a position near the furnace.

This method of preparing the charge is so simple that two laborers can readily prepare the charges for both furnaces, each pouring 5 heats daily, and yet have time to wheel in and break the ferro-alloys, iron ore, etc., and perform the other necessary miscellaneous labor about the furnace. As soon as one crane takes the ladle of molten metal from the furnace, another crane picks up a scrap pan and starts charging. Fig. 3 illustrates this process easier than it can be described.

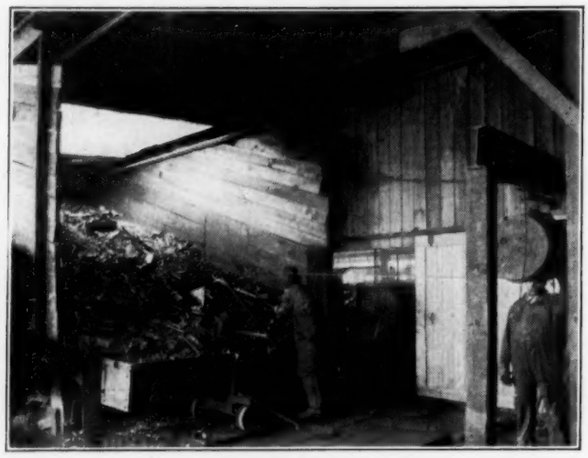


FIG. 2.

As a rule, 2 pans of foreign scrap, or approximately 8000 pounds are thus charged, after which the remaining 3000 pounds of the charge, consisting of foundry returns and turnings are charged by hand. Thus, approximately a 5½ to 6 ton heat may be charged in less than 8 minutes. If the charge consists of all foreign scrap, 3 pans full are used. In this case the charging time is 4 minutes. Two laborers and the crane operator suffice for the charging.

The kilo-watt hour and electrode consumption and the time per ton are all influenced by the charge. The mass should be compact, and yet not too dense. A compact charge such as an all punchings heat, will form a pool on the surface, which works downward through the charge very slowly and consumes valuable current and time. Obviously this increased time would favor greater electrode consumption. On the other hand, with too loose a charge, the electrodes will rapidly bore through the charge to the bottom of the furnace, forming a small pool upon which the arc plays. Not only is this undesirable to the bottom, but it prevents ideal steady operation. The arc is unstable and the electrodes hunt appreciably. Obviously there is a slight loss of heat at the interruption of each arc. Consequently the kilowatt hours, electrode consumption, and time are increased. With a proper charge the electrodes will gradually bore through the charge, reaching perhaps ¾ of the way to the bottom to form a pool and then slowly rise. The arcs are very stable. The current, time, and electrode consumption will be at a minimum. While the above information apparently should be known to all furnace operators, it is surprising to know the number of operators with whom the writer has come into contact, who are either ignorant or careless of the proper charging procedure. This is the only excuse the writer has for including such an elementary topic in this paper.

To save valuable heat, and consequently current and time, after the last heat of the day has been tapped, a couple scoops of soft coal are scattered in the furnace, the electrodes lowered, and all openings around the doors and electrodes sealed with sand. The next morning the furnace will be almost white hot. The author realizes that the electrode manufacturers recommend raising the electrodes, and allowing them to cool rapidly in the open, but in our plant at least, we have found the above to be the best procedure.

The author does not wish to discuss the relative merits of carbon versus graphite electrodes. Both are good, although we are inclined to be partial to graphite. The electrode consumption shown in the table is quite good, although the author is inclined to believe the figures for January and February may be slightly wrong, due possibly, to a mis-count of the number used.

Our net tons per roof are poor, although considering the extra high temperature of the metal, it is apparent better results should be had for more standard practice.

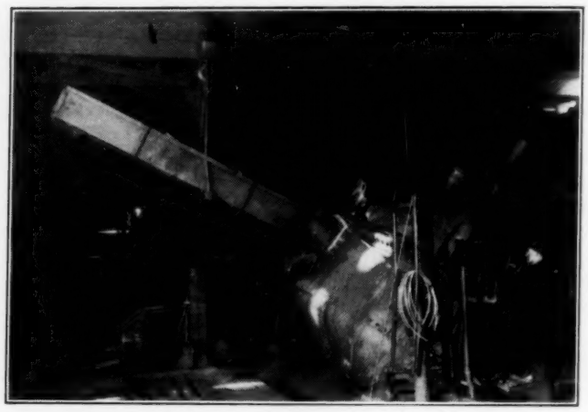


FIG. 3.

The figures for the net tons per side wall are misleading unless explained. The entire shell (bottom and side walls) is lined with a rammed in ganister lining. Repairing the side walls is simple and cheap. One man can easily do the work in less than 4 hours per every 1150 tons. The bottom is built up by shoveling in crude silica sand and turnings. These fuse to form a firm, dense bottom.

It may be interesting to know that with this all-ganister lining, the original bottoms are intact in both furnaces. The original side wall of one furnace and part of the original side wall of the other is intact. Part of the original side wall of the older furnace was recently removed to replace some rivets which had worked loose. This riveted type of shell has been superseded in the present design of the manufacturer by a superior welded construction. This lining life is ideal when we consider that one furnace has been in operation almost 8 years, pouring over 7900 heats. Figuring these heats conservatively as averaging 5 tons each, we have poured over 39,000 tons from the original bottom and from all indications it is good for the same number again.

Some Furnace Costs

In Table No. 2 is shown electric furnace costs covering a 4 weeks' period. This indicates what metal costs may consistently be attained by good furnace practice during normal business conditions.

TABLE NO. 2

Electric Furnace Cost

Four Week Period

Direct Material	$12,449.11
Direct Labor	670.58
Direct Labor Bonus	132.50
Direct Labor Overtime	25.94
Indirect Labor	335.07
Indirect Labor Bonus	58.00
Indirect Labor Overtime	11.22
Supplies	633.31
Electrodes	990.31
Electric Current	6,973.92
Gas	88.55
Lighting Supplies	1.22
Maintenance of Equipment	334.12
Industrial Insurance	6.44
Depreciation Allowance on Equipment	464.09
Insurance on Equipment	30.47
Taxes on Equipment	57.26
Maintenance Direct Labor	56.35
Maintenance Direct Material	15.53
Tool Direct Labor	.88
Factory Administrative	89.91
Maintenance Burden	17.47
Power and Light	110.94
Occupancy Foundry Building	172.06
Cranes	59.11
Materials	51.69
Laboratory	310.70
Tool Burden	1.01
Total	$24,178.36
Less value scrap recovered	2,310.78
Grand Total	$21,867.58
Good Pounds Produced	1,170,948
Cost per pound	$0.01868

While the table is self explanatory, the author will briefly describe several items in it.

Direct material includes the various metals and ferro-alloys comprising the charge, but does not include any ladle deoxidizers. A typical charge, during this period is shown in Table No. 3.

TABLE NO. 3

Direct Material Cost for Same Period, Per Heat

	Per Pound	Charge in Pounds	Cost
Foreign Scrap	$.00765	8100	$61.97
Return Scrap	.00658	1700	11.19
Turnings (Own)	.00536	1700	9.11
50% Fe-Si	.03636	80	2.91
80% Fe-Mn.	.05000	125	6.25
Iron Ore	.00339	350	1.19
		12055	$92.62

Under direct labor are entered the wages of the head melter, who supervises both furnaces. He is paid $.90 per hour. In addition, we employ one operator to each furnace at $.80 per hour. Overtime is paid after 9 hours. In addition these men receive a substantial bonus based on the pounds of good castings produced per man hour.

Under indirect labor are those men bringing in and weighing the charges, removing and dumping slag pans, ladle men, and the work of repairing the roofs and side walls. The labors average $.50 per hour and are paid for overtime over 9 hours.

Aluminum, ferro-titanium, bottom pour ladle stoppers and sleeves, etc., are listed under supplies. Electric current is bought on a sliding rate, averaging $.015 per kilowatt hour. Ladles are dried and heated by gas. The indicating lamps for the switchboard are listed under lighting supplies. Maintenance of equipment includes the material used for repairing the roofs, side walls, and ladles.

The work of the plant electrician, millwright, and oiler upon the furnaces is listed under maintenance direct labor, while the oil, paint, or other material required for their work comes under maintenance direct material. The remaining items should require no explanation. Note that the cost per pound is figured on the basis of good castings produced, and not upon the actual pounds poured.

ELECTRIC FURNACE CAST IRON

Cast iron is perhaps our oldest ferrous material of construction. For generations it has been the preferred material for such parts where cheapness combined with moderate strength and resistance to wear were of paramount importance. Hence its popularity for machine parts, engine bed plates, housings and so forth.

However, for many years little improvement was made, either in quality or method of manufacture of cast iron, while drastic improvements were being made in the other ferrous fields such as steel castings, forgings, welded parts, etc. It is no wonder then that iron castings were being rapidly replaced by other more reliable materials and the entire iron foundry industry threatened and in danger of rapid elimination unless radical improvements were made in quality. To counteract this peril very extensive research was done, both in this country and in Europe, so that what a few years ago was considered a very good iron, now cannot pass specifications. In fact, more improvements were made in this field in the few years following the War than in 50 years preceding it.

Only a few years ago good cast iron would average 20,000-25,000 pounds per square inch tensile, now it can consistently be made to average over 40,000 pounds, while alloy irons are made with strengths better than 70,000 pounds per square inch, or on a par with low carbon steel castings and actually having an elongation of 1.0-1.5%. The transverse breaking strength has been correspondently improved, namely from 2900 pounds to 4500 pounds on the plain unalloyed arbitration bar. In fact, the weak, brittle iron of a few years ago bears little resemblance to the strong, tough iron of today.

While all the betterment of gray iron cannot entirely be directly attributed to the electric furnace, the fact remains that the electric furnace has played an important role in its improvement.

Perhaps the first application of the electric furnace to the gray iron industry was made by Elliot, of the Lunkenheimer Company, who duplexed gray iron from the cupola to the electric furnace, where he held it under a calcium slag for the purpose of desulphurizing and deoxidizing the material for high grade valve body castings.

Obviously a high calcium or lime slag will be very basic, necessitating a basic lined furnace for the best results. Therefore a discussion of this process is outside the scope of this paper.

Superheating

The cupola is unquestionably usually our cheapest melting medium; also its first cost is considerably lower than that of an electric furnace installation. It is no wonder then, that the electric furnace, while it rapidly replaced other melting mediums in the steel industry, especially in the light and medium casting field met considerable opposition when it entered the iron foundry. The demand for both improved gray iron and malleable castings was, and is, so great today that the electric furnace is the only logical solution.

The cupola as we know, even in skilled hands is as temperamental as any grand opera singer. Today it will produce nice hot metal resulting in good, sound castings—tomorrow the iron will be cold, the castings dirty, full of blow holes and shrink holes and cracks. What foundry man has not encountered this condition? The direct arc electric furnace will always produce hot iron. With it, there is no excuse for misruns or cold shuts, even in the lightest and thinnest section. The analysis is always under control of the furnace operator, and he can readily pour at the temperature best suitable for the particular casting. No iron need be pigged, using the electric process.

Good castings are a natural result of hot electric furnace iron. Misruns and cold shuts are at a minimum, heads and sprues may be reduced, a very desired economy. The ease with which a reducing atmosphere can be maintained in the furnace results in a thoroughly deoxidized and degasified product and consequently a denser closer grained product. This dense, close grain is an inherent property of electric furnace iron, and always causes favorable comment when shown to an old time foundryman for the first time.

Everyone will admit that a dense, close grain metal is stronger than an open, coarse grained metal —but how much stronger is it? To answer this, the writer had a test bar poured of cupola iron at a nearby foundry. Upon analysis, it was found to consist chemically of

Total carbon	3.60
Graphitic carbon	2.88
Combined carbon	.72
Silicon	1.66
Manganese	.57

and upon physical tests

Brinell hardness	217
Tensile	22,250 lbs. per sq. in.

Temperature readings were taken and at the cupola spout was found to be 2420° F. the pouring temperature 2360° F.

The author specifically ran a heat to duplicate both this analysis and temperature in a 50 pound Laboratory type furnace with the following result:

Total Carbon	3.56
Graphitic Carbon	2.94
Combined Carbon	.62
Silicon	1.78
Manganese	.64
Brinell	235
Tensile	31,500 lbs. per sq. in.
Furnace temperature	2430° F.
Pouring temperature	2360° F.

By a mere change of melting medium, the two analyses being considered practically the same, an increase of over 9,000 pounds per square inch was obtained. This slight gain alone may be directly attributed to the denser, closer grained electric furnace iron.

During recent years much has been written about superheated iron, that is iron which has been subjected to a superheat of from 200-500° F. hotter than usual. These extra few hundred degrees, easily obtained in the electric furnace but difficult in the cupola, opens a new field in high test gray iron. Without any alloy additions or considerable change of analysis, a gain of about 10 tons per square inch may be consistently attained.

The best strengths appear to be obtained by pouring the superheated metal at relatively high temperatures. In a test, two bars were poured from a laboratory heat of metal superheated to 2900° F. The one bar was poured at 2900° F., the temperature then allowed to drop to 2500° F. and another bar poured. The first bar showed an increase 8,000 pounds per square inch tensile over the one cooled to 2500° F.

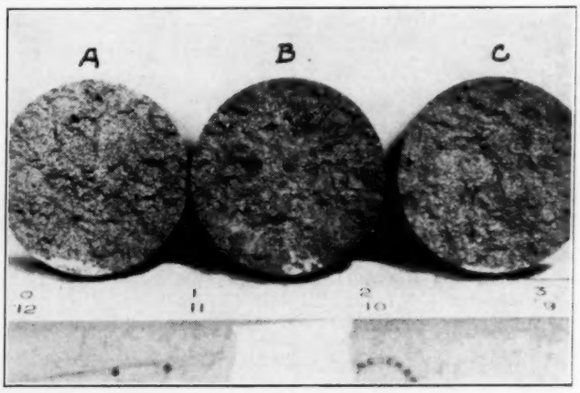


FIG. 4.

In Figure 4, are photographs of 3 broken transverse bars poured from a heat of cast iron melted in a laboratory type of electric furnace. Bar (a) was poured when the metal reached 2500° F., bar (b) at 2900° F., in (c) the superheated metal was allowed to cool to 2500° F. before pouring.

Irons poured at a high temperature occasionally show dendritic structures, as shown in (b). These structures may be easily removed by a simple anneal. In fact, it is the practice of our plant to anneal all cast iron castings. However, ordinary electric gray iron castings need not be annealed. The dendritic structure is often encountered when slow cooling is encountered. Of course for ordinary castings where the greatest possible strength is not required, the superheated iron would be poured at a lower temperature, thus eliminating the possibility of obtaining the dendritic structure.

The several theories regarding superheating are beyond the scope of this paper. The classical works of Piwowarsky are available to all who may be interested in this phase of the subject.

I cannot leave the subject of superheating without calling attention to the outstanding characteristic of

this metal, namely, the graphitic structure revealed by the microscope.

Ordinarily, graphite in cast iron takes the form of coarse plates, flakes, streaks and blotches familiar to all. But when subject to superheat, these coarse particles are broken up, they are very finely divided, and uniformly distributed throughout the metal. The primary natural cause of weakness and brittleness of cast iron is thus automatically eliminated and the resulting material is much stronger and tougher than before.

Superheated iron does not exhibit as much grain growth, either under prolonged or intermittent exposure to heat as the ordinary gray iron of the same analysis, making it admirably suitable for castings exposed to mild temperature fluctuations.

Another peculiarity of this superheated iron is the marked freedom from casting strains. Often for very accurate machined parts the castings need not be artificially aged or annealed before machine work is done upon them. Yet they do not warp when the surface skin is removed.

Disregarding the subject and theory of superheat, a very decided advantage of the very hot electric furnace iron is the case with which very light and thin sections may be poured. I refer to that class of gray iron castings that with ordinary cupola iron must be poured with very high phosphorous in order to get the necessary fluidity. High phosphorous weakens the iron, especially for those castings subject to impact, shock, or repeated vibrations. Also, especially if the foundry has much of this class of work, needless expense and confusion arises due to the need of carefully segregating the high from the low phosphorous iron, both in the raw material and the foundry scrap. The electric furnace will require only one grade of scrap, the necessary fluidity being readily attained by the high temperature possible in this unit.

Foundry men accustomed to the pouring of white iron for malleable castings realize the extremely small temperature range existing between the air furnace metal and the lowest possible pouring temperature for sound castings. In fact, with their practice, cold metal, with its attended evils is a constant source of difficulty in the malleable game. Here again, hot electric furnace iron is the logical solution of the problem.

As a brief summary we may say that the electric furnace, operated as a melting unit only, and without recourse to alloys or improved analysis and metallographic structures, to which reference will be made later in the paper, gives us an iron, either gray or white, vastly superior to that possible by any other existing unit. The hot, deoxidized and degasified iron will reduce our defective castings; while the ease of superheating and holding at superheat temperatures, opens an unlimited field for high test iron.

Alloy Cast Iron

During the past decade there has been a surprisingly large demand for alloy iron castings, not only for heat and corrosion resisting purposes, but also for high strength, and shock and wear resisting castings.

Alloys, as a rule, are very expensive and their useful working range limited. Obviously it is an economical necessity for the producer of alloy iron castings to use that process which will give him the greatest yield for the alloy added, together with consistent analysis from one heat to another.

Every cupola tender who has attempted pouring a special tap of metal during the regular days run knows the difficulty of keeping that charge separate from the balance of the heat. Even though he separates that charge from the others by an extra heavy layer of coke there is a question in his mind just when that charge comes down. Unfortunately for him the entire charge does not melt uniformly; part of the more fusible constituents may melt before the balance of the charge reaches the melting zone, and drip down into the preceding charge; some may hang up and not melt until the following charge comes down. Again, as is usually the case, the entire charge is not taken out in a large bull ladle but in small hand ladles. Since we have no assurance that the entire charge is melting uniformly and the alloy thoroughly disseminated throughout the mass, it requires no strentch of the imagination to conceive of one ladle being rich in the alloy and the other poor.

The average cupola is notorious for producing cold iron just when we need extra hot metal; the heat may have been extra hot throughout the day but just when we are ready to throw a high melting point alloy into the ladle, the iron comes cold. Practically all of our alloys have a fairly high melting point, approaching that of molten iron. They dissolve with difficulty in the ladle.

The ease with which these additions are made in the electric furnace, and the high yield therefrom, should recommend this medium to all specializing in alloy gray iron.

While the properties of alloy irons may be familiar to all, I will briefly review the most important.

Nickel: Nickel acts as a graphitizer or softener of iron, the same as does silicon, although not to the same extent. It reduces shrinkage permitting complicated castings to be made free of cracks.

Nickel toughens the matrix, giving increased strength and wearing qualities. Grains size is decreased to a marked extent, producing a close, dense metal. This element has a marked influence upon machine ability; high brinell irons containing nickel machines easier than lower brinell irons not containing it. In addition, nickel irons are less sensitive to cooling rates, thus giving greater uniformity between thick and thin sections, and at the same time preventing chilled or hard corners and edges. Nickel is not subject to oxidation, and thus may be added to the furnace directly with the charge; also the scrap nickel castings may be remelted without loss.

As an illustration both of the graphitizing power of nickel and the increase in strength possible with it, compare the following two electric furnace heats:

Total carbon	2.67	2.65
Graphitic carbon	1.89	2.04
Combined carbon	.78	.61
Silicon	1.63	2.28
Manganese	.98	1.08
Phosphorous	.117	.116
Sulphur	.053	.053
Nickel	1.06	.03
Tensile	59,500	41,750
Brinell	269	255

Test bars were 1 inch diameter as cast; Machined to 0.505 inch diameter, 2 inch gauge length.

Chromium: Chromium is the direct opposite of nickel in that it is a hardener of iron; that is, it prevents graphitization. It increases chill and even

with small amounts increases brinell hardness together with difficulty in machining, due to the fact that chromium not only prevents the breaking down or graphitization of the iron carbide, but at the same time forms a double iron chromium carbide which crystallizes with the pearlite.

So great a restrainer of graphitization is chromium, that only a few tenths of a percent of this element makes malleablizing difficult, while 0.5% renders the process commercially impossible.

Even in small amounts chromium increases the tensile, transverse, hardness, and shock resisting properties of iron, in amounts above 0.80% the tensile strength again decreases. In suitable proportions it prevents growth at elevated temperatures and also increases corrosion resistance.

Due to its low cost it is rapidly gaining favor as an alloying agent of cast iron.

Chromium oxidizes readily and consequently is not added directly with the charge. We prefer throwing the ferro-alloy into the furnace just prior to tapping, although excellent results are obtained by ladle additions.

Chromium-Nickel—While either of these elements by themselves improve gray iron, the greatest benefit is obtained by using them in combination. When used in the correct proportion, the hardening effect of chromium will balance the softening effect of nickel. Chrome-nickel irons as a rule, will contain 2½ parts of nickel to 1 part of chrome. This iron is useful for such applications where fine grained structure, combined with hardness, strength, and wear resistance are essential in easily machined castings.

Molybdenum: The addition of molybdenum to cast iron increases the tensile and transverse strengths, improves the wear resisting qualities and greatly increases its shock resistance. In amounts below 0.5% molybdenum increases the brinell hardness slightly, but not at the expense of easy machining. Not only does molybdenum refine the grain, but it also refines the graphitic carbon, the graphite taking characteristic hook or whorl forms.

Molybdenum may be obtained either in the form of ferro-molybdenum or calcium molybdate. The ferro-molybdenum may be added directly to the charge, while we prefer adding the calcium molybdate when the charge is about half melted. Molybdenum scrap may be remelted with full recovery.

The author recently had occasion to remelt a heat of brake drums containing molybdenum which were returned to the foundry due to a pattern defect. These drums were about 19 inches in diameter ½ inch metal thickness and weighing in the neighborhood of 60 pounds. They analyzed 2.89 total carbon, 0.72 combined carbon and 0.36 molybdenum. Since these drums were too bulky to charge in any quantity, it was necessary to break them. Two laborers, armed with sledge hammers, attacked the pile, but at the end of 30 minutes had succeeded in breaking only 8 drums. We then decided to drop a 2400 pound ball on each drum separately from a height of approximately 6 feet. The supposition was that these drums being of cast iron would be instantly shattered, but at the end of a half dozen drops the iron was merely cracked. The dropping height was then raised and at 20 feet it took two and three drops of the ball to tear the drums apart, and several more attempts to reduce them to appropriate size for the charging pan. So tough was this iron that a tearing, instead of a shattering phenomenon took place.

Unquestionably, only a high grade alloyed, electric furnace gray iron would meet this test.

Other alloys—while nickel, chromium and molybdenum are the commonly used alloys, other elements, such as aluminum, titanium, copper, tungsten, and vanadium are used to meet specific requirements. Their use is so limited at the present time that we will not go into detail about them.

Improved Analysis and Metallographical Structures

Mr. Coyle, in a recent technical paper, made the statement that "gray iron may be thought of as being simply steel interspersed with graphite." While this statement is not strictly true, it will suffice for the purpose of this paper.

Graphite has a negligible strength compared to iron. Its specific weight is about one quarter that of iron. Consequently a gray iron containing 3% graphite by weight, would have 12% graphite by volume being therefore much weaker than a pure iron. If these graphitic particles occur in large plates and blotches, they will seriously affect the continuity of the metal. The statement is obvious therefore that an iron containing a small percentage of graphitic carbon, the individual graphite particles being very fine and uniformly distributed is stronger (all other factors being constant) than a higher graphitic iron, containing large graphite segregations.

A low graphite gray iron naturally presupposes a low total carbon content.

Carbon in iron exists in two forms, free and combined. This combined carbon, known as iron carbide (Fe_3C) or cementite, is the hardest constituent encountered in iron; it also is very brittle. The carbon in white iron is all combined. This iron is hard and brittle. In gray iron the carbon exists both as free graphite and iron carbide. The greater the amount of iron carbide, within certain limits, the harder and stronger is the iron.

Under the microscope, when the combined carbon is approximately 0.85-0.90, the entire matrix is revealed as a definite metallographical structure known as pearlite, a laminated structure consisting of alternate layers of ferrite and cementite. Below this eutectic, the matrix, will be pearlite-ferrite, while above it, pearlite-cementite.

It has long been known that one of our strongest structures in steels is a pearlitic one. From our simple definition that gray iron is simply steel interspersed with graphite, we can readily deduce that our strongest iron will also have a pearlite structure.

While an iron having approximately 0.85% combined carbon will have an entirely pearlitic matrix, the author has found, for his particular class of work at least, that for electric furnace iron, the strongest castings will analyse 0.75% combined carbon. Under the microscope this is revealed as being practically an entirely pearlitic matrix.

While no definite statement may be made, variables such as casting thickness, pouring and cooling rates, etc., must be taken into consideration, a rather broad rule, and one applying in the majority of cases, is that, the strongest iron will be produced when the sum of the total carbon and silicon equal 4½. The combined carbon will then approach the eutectic, and the matrix be pearlitic.

Earlier in this article the author made the statement that low total carbon produced the best results,

but he did not specify the carbon range. Above 3% total carbon, graphitization takes place so rapidly that it is practically impossible to control the graphite forms or sizes, below 2% graphitization is produced with difficulty. The strongest irons will be formed around 2.5-2.9 total carbon.

It is entirely possible to produce this low carbon iron in the cupola by means of suitable steel additions, but much difficulty will be experienced in controlling the analysis if hot metal is required. Molten iron, trickling through a hot coke bed, readily absorbs carbon, especially at elevated temperatures. In the electric furnace there is no such carbon pickup and low carbon pearlitic irons with controlled graphite size and forms are readily produced.

Synthetic Cast Iron

During and immediately following the war considerable research and also production work was done on the Pacific Coast on the synthetic production of gray iron. A peculiar situation exists in that territory. Steel scrap is abundant, pig iron is expensive, while electric power is comparatively cheap. The carburization of cheap steel scrap was an economical necessity if a cheap cast iron was desired. This process also had the advantage of producing an extremely low phosphorous and sulphur iron, merely by the selection of the proper scrap.

Carburization was undertaken at first by means of coke. Later silicon carbide and petroleum coke were substituted. The essential requirement of this process is a source of very high carbon material, having a very low ash content. The best results are obtained by adding the carburizing material in small amounts at a time, upon the bare bath and poling it in.

Carburization takes place rapidly at high temperature. A low silicon content is not essential for a fast pickup.

Additional Advantages of Electric Furnace for Cast Iron

Perhaps the greatest advantage of the electric furnace is the ease with which any analysis may be so readily obtained. There is no excuse whatsoever for pouring an off analysis heat, silicon, carbon and manganese may be instantly adjusted. If necessary, the metal can be held until a preliminary analysis has been taken.

For ordinary routine iron however, we do not wait for a chemical test, there are several easy, certain and safe physical tests upon which we can rely.

The first is what we call the chill test. In this a pattern, ¾ inch thick, 1½ inch wide and 4 inches deep is sunk in a green sand mold, the 1½ inch face being imbedded against a piece of ¾ inch mild steel plate, 4 inches deep. This plate acts as a chill; the depth of chill desired depending upon the casting wanted. This test is accurate only when conducted under carefully regulated conditions. The molten iron must always be poured into the mold at the same temperature; the piece being allowed to cool in the sand until only a trace of color is seen when shaded by the hand. The piece is then drawn from the mold, quenched in water and broken. From the appearance of the fracture an experienced operator can easily determine whether the iron is too hard or soft for the desired casting, and also if the silicon or the carbon must be raised. In Fig. 5, are shown several typical broken chill tests; the piece above the number five on the scale being the one suitable for a ½ inch section where a brinell hardness of 255 is desired.

The second is the wedge test. This we believe to be more accurate than the chill test. It is not as critical to pouring temperature as the chill test is. In this method a tapered pattern 10 inches long, 1 inch wide and tapering from a point at one end to a 1 inch thickness at the other end is imbedded in green sand. The mold is poured by means of a

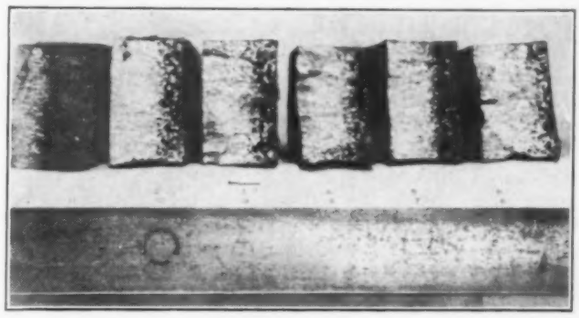


FIG. 5.

small, well slagged test dipper, and the wedge is withdrawn as soon as it is black. It is quenched in water and broken at various sections. In this method the appearance of the fracture is noted both at the section corresponding to appearance. The appearance of several fractured wedge are shown from sections ¼ inch and ⅝ inch thick in Fig. 6.

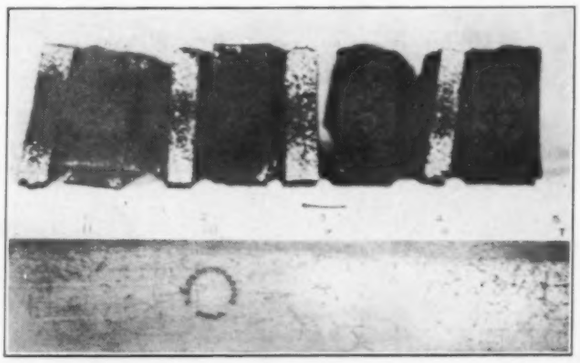


FIG. 6.

Note that we have specified green sand molds in both tests. It is absolutely essential for these tests to be poured into sand having the same moisture content and temperature as the mold will be. Of course if dry sand molds are used the test bars should likewise be poured in dry sand molds.

While the above advantage of the electric furnace for cast iron appeals strongly to the plant chemist, or the operator responsible for the proper analysis of the metal, the plant superintendent is interested mainly in the cost of the product. Pig iron is costly when compared to scrap or borings. The electric furnace is not dependent on pig iron. In fact, if scrap of the proper phosphorus and sulphur content is available, no pig iron whatsoever is required. Since properly made electric furnace iron is stronger than cupola iron, these two injurious elements may safely be carried higher than for cupola practice and yet produce a superior metal.

The author has poured many electric gray iron

heats during the past two years, starting at first with considerable iron, and gradually reducing the pig until now all heats are made of scrap. There is no difference in strength between the pig iron and the all scrap heats. Pig iron is not required. This results in a decided economy. In addition the still cheaper borings may be melted with advantage. We find that these borings may be charged directly without the necessity of briquetting. Any one who has attempted melting borings in a cupola knows that good operation requires that these borings be briquetted and even then the yield is low.

Since we machine all of our castings: borings, both fine and coarse, are a necessary evil with us. Early in our electric cast iron experience we were afraid of borings with the natural result that in a very short time quite a large pile had accumulated. As an experiment, the author decided to melt a 4-ton heat composed entirely of these loose borings. The yield was 78% for the first attempt even with heavily rusted borings. The finished product could not be distinguished either physically or chemically from the regular castings.

Since then borings constitute a portion of all our charges. Never has there been an occasion for briquetting them.

The speaker firmly believes that the use of low cost scrap and borings in place of pig iron, will more than offset the higher melting costs of the electric furnace and the latter can compete favorably with the cupola especially in the production of high grade cast iron.

Cupola iron is notorious for its high sulphur pick-up. In the electric process there is no possible pick-up. The speaker is in no position to positively state what the maximum sulphur content of gray iron should be. That is the problem of the individual foundry, and depends greatly upon the casting. However, if a low sulphur content is essential, the non-pickup of sulphur in the electric furnace is vital factor in the selection of the proper melting unit.

Pouring Alternate Heats of Steel and Cast Iron

Low carbon steels and cast irons differ so greatly in their chemical analysis that the natural supposition is, elaborate precautions must be taken when alternating steel and cast iron. This is not true. Only two simple rules must be followed. First, the side walls must slope freely towards the top hole in order to easily drain the furnace. Second, the furnace must be completely drained both of metal and slag. If a small pocket or hole traps some iron, a heavy metal rod is worked in the molten mass, chilling and balling it around the rod, so that it is very easily removed.

A small amount of either metal remaining in the furnace has not serious effect. Larger amounts of cast iron freezing in the furnace necessitates additional ore in the following steel heat. If steel remains, a little coke will remedy it when melting cast iron.

Tabulated Data in Connection With Lubrication Engineering Division's Questionnaire

The following tabulated data was secured from a questionnaire sent to the Iron and Steel Plants. This questionnaire is not a recommendation. It simply represents the present practice of about 65 per cent of the Steel Mill Tonnage in the United States.

The Lubrication Engineering Division will be glad to have any Steel Plant executive's criticism of this tabulation, both as to the type of lubricant used and the method of application on any particular type of apparatus or equipment shown in the tabulation.

This tabulation will be printed once each year, taking into consideration when it is being compiled, the criticisms and suggestions offered by the Steel Plant Lubrication Executives.

Unless otherwise noted all viscosity mentioned in the Tabulated Data is at 100° F.

CRANES

GENERAL PURPOSE, GANTRY, JIB AND DERRICK

Equipment	Type of Lubrication	Method of Application
Worm Gear	600 Cylinder Stock	Splash and Bath
Mechanical Brakes	#3 Cup Grease	Bath
Spur Gear	A Heavy Asphalt Grease	Open—Swabbed
	Asphalt Base, soft grease to meet requirements.	If enclosed—Bath
Plain Bearings	#3 Lime Soap Grease	Screw Type Grease Cup
	#1 Lime Soap Grease	Hand Gun
	#1 Lime Soap Grease	Pressure Systems

Equipment	Type of Lubricant	Method of Application
Anti-Friction Bearings	Low Lime Soap Content and 200 second viscosity engine oil where water conditions exist. Many firms use a Soda Soap Base where water conditions do not exist.	Hand Gun or Pressure Systems
Truck Wheel Bearings—Plain	Majority favor Wool Waste and Oil.	Generally—Oil Cellar Boxes. M.C.B. Type
	Over heating furnaces—Wool Waste and 600 Cylinder Stock. Some firms use Wool Waste and Fluid Grease.	
Truck Wheels—Anti-Friction Bearings	See Item No. 5—Anti-Friction Bearings	Hand Gun or Pressure Systems
Wire Ropes and Cables	Generally an Asphalt Stock. A few use Cylinder Oil and Grease.	Brush-Swab-Grease Box
Electric Motors Sleeve Bearings	200 Second Viscosity at 100 deg. F. zero cold test for winter. 200 Second Viscosity at 100 deg. F. regular for summer.	Ring Oiled
Electric Motors Anti-Friction Bearings	See Item No. 5—Anti-Friction Bearings.	Grease Gun

LADLE, INGOT STRIPPERS, SOAKING PIT CRANES AND CHARGING MACHINES

Equipment	Type of Lubrication	Method of Application
Stripper Screws	600 Cylinder Stock or some oil near this flash point.	Bath and Splash
Worm Gears	600 Cylinder Stock in majority of cases; light transmission grease in a few instances; lead base stock in a very small number reporting.	Splash
Spur Gears and Bevel Gears	2600 Second Viscosity at 100° F. Asphalt Pitch.	Swabbing
Bearings—Plain	Light Steam Refined Cylinder Oil	Hand with Can
Bearings—Anti-Friction	Lime Soap Base Grease	Force Gun
Wire Ropes and Cables	1700 Second Viscosity Asphalt Pitch	Hand with Swab
Electric Motors	153 Second Viscosity Oil	Oil Rings
Truck Wheel Bearings	Light Steam Refined Cylinder Oil—Wool Waste	Hand with Can
Anti-Friction Bearings	Lime Soap Base Grease	Gun
Racks or Screws for Chargers	On Racks—2600 Second Viscosity Asphalt pitch	Hand with Can
	Screws—Heavy Steam Refined Cylinder Oil	Bath
Turn Tables	Balls and Race—Good grade of #2 Cup Grease	Hand

CAR DUMPER, ORE BRIDGE, LARRY CAR, SKIP HOIST, LADLE CARS

Equipment	Type of Lubricant	Method of Application
Car Dumper		
Plain Bearings	Summer—Light Steam Refined Cylinder Oil	Hand with Can
	Winter—225 Second Viscosity, low cold test	Hand with Can

Equipment	Type of Lubricant	Method of Application
Motor Bearings	150 Second Viscosity, Low Cold Test	Hand with Can
Wire Rope, Cable	1700 Second Viscosity Asphalt Pitch	Swabbing
Gears	2600 Second Viscosity Asphalt Pitch	Swabbing
Lineshaft Bearings	Summer—Light Steam Refined Cylinder Oil	Hand with Can
	Winter—225 Second Viscosity, Low Cold Test	Hand with Can
Track Wheel Bearings	Light Steam Refined Cylinder Oil and Wool Waste	Hand
Ore Bridge		
Plain Bearings	Summer—Light Steam Refined Cylinder Oil	Hand with Can
	Winter—225 Second Viscosity, Low Cold Test	Hand with Can
Motor Bearings	150 Second Viscosity Low Cold Test	Hand with Can
Wire Rope, Cable	1700 Second Viscosity Asphalt Pitch	Swabbing
Gears	2600 Second Viscosity Asphalt Pitch	Swabbing
Lineshaft Bearings	Summer—Light Steam Refined Cylinder Oil	Hand with Can
	Winter—225 Second Viscosity, Low Cold Test	Hand with Can
Buckets	Black Oil	Hand with Can
Truck Wheel Bearings	Light Steam Refined Cylinder Oil and Wool Waste	Hand Oiling
Larry Car		
Truck Wheel Bearings	Light Steam Refined Cylinder Oil and Wool Waste	Hand Oiling
Motor Bearings	Summer—225 Second Viscosity Oil	Hand Oiling
	Winter—225 Second Viscosity, Low Cold Test	Hand Oiling
Ladle Cars		
Track Wheel Bearings	Light Steam Refined Cylinder Oil and Wool Waste	Hand Oiling
Skip Hoist		
Motor Bearings	225 Second Viscosity Oil	Hand
Wire Rope, Cable	1700 Second Viscosity Asphalt Pitch	Swabbing
Skip Car Track Wheels	Light Steam Refined Cylinder Oil and Wool Waste	Hand
Skip Hoist Drum Bearings	Light Steam Refined Cylinder Oil	Hand
Steam Engines		
Cylinders	600 W Cylinder Stock Compounded with Tallow or Degras	Lubricator
Journals	225 Second Viscosity Oil	Oil Cup
Crank Pins	225 Second Viscosity Oil	Oil Cup
Twist Pins	225 Second Viscosity Oil	Oil Cup
Cross Head Guides	225 Second Viscosity Oil	Oil Cup

BLOOMING, STRUCTURAL AND PLATE MILL

Equipment	Type of Lubricant	Method of Application
Pinion and Pinion Necks	1700 Sec. Viscosity at 100 deg. F. Oil	Circulation System
Pinions	2500 to 3000 Sec. Viscosity Asphalt Stock	Splash
Pinion Necks	400 Sec. Viscosity Oil. Some use Black Oil	Drop Feed
	Cylinder Oil Pump 400 Sec. Viscosity Oil. Some use Black Oil.	Force Feed
Reduction Gear Sets Gears and Bearings	1200 to 1700 Sec. Viscosity Oil at 100° F. High demulsibility.	Circulation Systems
Gears	Soda Grease and Cylinder Oil; Transmission Grease. Also 2600 Sec. Viscosity at 100° F. Oil.	Bath
Bearings	400 Sec. at 100° F. Viscosity Oil.	Ring Oil and Cylinder Oil Force Feed Pump
Roll Stands Roll Necks Anti-Friction Bearings	Majority favor Heavy Body Oil. Small percentage, Lime Soap Grease	Grease Gun
Plain Bearings Wood	Water	Large Volume Low Pressure
Brass	Heavy Tallow Compound. A few use 4 to 6% Graphite. Some 14% Graphite.	Hand Packed
	#3 Consistency Grease with a heavy tallow content 8 to 12% and 4 to 6% Graphite.	Pressure Grease Systems
Babbitt	(See Above)	(See Above)
Screwdowns	600 Cylinder Stock	Majority Use Drop Feed. Small percentage use force feed.
Universal Coupling	#1 Cup Grease; Lime Base	Pressure Gun
Sleeve Coupling	2500 Sec. at 100° F. Viscosity Asphalt Stock.	Hand Oiled
Manipulators and Side Guards		
Electric Motors	225 Sec. Viscosity Engine Oil	Ring Oiled
Gears and Racks	Majority use Asphalt Base 1700 Sec. Viscosity Grease	Splash
	A few use Transmission 1700 Sec. Viscosity Grease	Splash
	A few use Lead Base 1700 Sec. Viscosity Grease	Splash
Racks	Heavy Asphalt Compound	Swabbing
Crankshaft Bearings	Steam Refined Oil— 575 degrees flash	Oil Cups
	#3 Cup Grease; Lime Soap Base	Grease Cups
	(1) **Oil**—Steam Refined Cylinder Oil.	Pressure Systems
	(2) **Grease**—Heat Resisting Soda Base Grease with 600 Cylinder Stock.	
Table Rolls Plain Bearings	Mostly Black Oil	Old Mills—Hand Feed

Equipment	Type of Lubricant	Method of Application
	600 Steam Refined Cylinder Oil where hot. 400 Sec. Viscosity Engine Oil, normal heat. 225 Sec. Viscosity Engine Oil, cool condition.	New Mills—Oil Rings and a few, force feed.
Anti-Friction Bearings	#1 Consistency, high grade grease, mostly Lime Soap Base. Hot conditions, Soda Soap Base with Cylinder Oil.	Hand Grease Gun mostly
Bevel Gears		
For Table Rolls	2000 Sec. Viscosity Asphalt Compound 450 Sec. Viscosity Oil	Old Mills—Swabbing New Mills—Bath
Reduction Gears		
Sets for Table Rolls	Cool conditions, 350 Sec. Viscosity Oil. Hot conditions, 450 Sec. Viscosity Oil.	Bath
Bearings	#3 Cup Grease, ordinary	Grease Cup
	Black Oil	Oil Can
Gears	2000 Sec. Viscosity Asphalt Compound	Open or Bath

BAR, ROD AND BILLET MILLS, PINION STANDS AND TRANSMISSION GEAR SETS

Equipment	Type of Lubricant	Method of Application
Pinion and Pinion Necks	Black Oil Mostly. Steam Refined Cylinder in a few instances.	Old Mill—Drop Feed for Necks.
	1700 Sec. at 100 deg. F. Asphalt Stock	Old Mill—Bath Teeth
	1200 Viscosity Oil at 100 deg. F. high demulsibility.	New Mills—Circulating System
Reduction Gear Sets		
Necks and Gears	Majority favor 800 to 1200 sec. Viscosity Oil	Circulating System
Gears	Light Soda Base Transmission Grease, Cylinder Stock.	Bath
	Some 1200 Viscosity Oil	
Bearings	400 Viscosity Engine Oil	Continuous Circulating System
	400 Sec. Viscosity Engine Oil	Force Feed Through Oil Pumps
Bevel Gear Lineshaft Drives		
Bevel Gear and Bearings	400 to 600 Sec. Viscosity at 100 deg. high Flash Oil.	Circulating System
Bevel Gear—Open Case	2600 Sec. Viscosity at 100 deg. F. Asphalt Compound	Swab
	Bearings Black Oil mostly	Old Mills—Hand Oiled
	400 to 600 Sec. Viscosity Oil	New Mills—Circulating System
	Normal heat, no water—#1 Soda Soap Grease 400 Sec. Viscosity Oil.	New Mills—Anti-Friction
	Normal heat, some water—#1 Lime Soap Grease 200 Sec. Viscosity Oil.	

STEAM HAMMERS

Equipment	Type of Lubricant	Method of Application
Steam Cylinders	Cylinder Oil Compounded with tallow or degras.	Mostly force feed. A few, hydrostatic Hand Oiled.

Equipment	Type of Lubricant	Method of Application
FORGING PRESSES		
Steam Cylinders	Cylinder Oil Compounded with tallow or degras.	Force Feed
Columns	Cylinder Oil Compounded with tallow or degras.	A few swabbed
MILL DRIVE ENGINES		
Steam Cylinders	Cylinder Oil Compounded with tallow or degras.	Force Feed
Journal Crank and Guide	225 Sec., Viscosity Engine Oil Note: One large firm, 153 Sec., viscosity engine oil.	Circulation System
Eccentrics	225 Sec., Viscosity Engine Oil	Circulation System
	#3 Lime Soap Cup Grease	Grease Cups
SERVICE AND HYDRAULIC PUMPS		
Steam Cylinders	Cylinder Oil—same as above	Force Feed
Water Plungers	50% use 1700 Sec., Viscosity Base Stock cut with engine oil.	Swab
	Some prepared plunger grease. One firm—a castor oil grease and graphite.	Swab
GAS BLOWING ENGINES		
Gas Cylinders	Steam Cylinder Stock—600 deg. F. Fire. One firm—600 deg. F. Compounded Vegetable Oil	Force Feed
Air Cylinders	Highly Refined 180 Sec., Viscosity Engine Oil.	Force Feed
Journals	225 Sec., Viscosity Engine Oil. Also, one firm—155 Sec., Viscosity Engine Oil.	Circulation
Eccentrics	225 Sec., Viscosity Engine Oil. Also, one firm—155 Sec., Viscosity Engine Oil.	Circulation
CHIPPING AIR HAMMERS		
Cylinders	Engine Oil 200 Sec., Viscosity. One firm, 160 Sec., Viscosity Castor Oil, 60% paraffin.	Hand
Belting	Mostly cling surface or stick (prepared) One firm—large belts, castor oil.	Hand
MACHINE TOOLS		
Bearings	225 Sec., Viscosity Engine Oil (mostly). New tools—pressure system complete.	Hand
Gears	1700 Sec., Viscosity Asphalt Compound	Swabbing
Drives	225 Sec., Viscosity Engine Oil	Hand—Old Style Pressure—New Style
Motors	225 Sec., Viscosity Engine Oil	Ring Oiled
	#1 High Grade Lime Grease	Anti-Friction Bearings Pressure
Belts	Generally Stick Compound	Hand
Pulleys	#2 Lime Soap Cup Grease	Hand—Grease Cups

TURBINES

Equipment	Type of Lubricant	Method of Application
Turbines	150 to 200 Sec. Oil. High demulsibility	Force System
Filter Apparatus	Mostly filters with centrifuge attached. A few with filters only. One with filter and water leg to settle out water and sludge.	

MOTOR GENERATOR SETS

Motor Generator Sets—Main Motor Drives	150 to 225 Viscosity Oil— some use regular turbine oils, others, regular engine oil.	Force System with filters

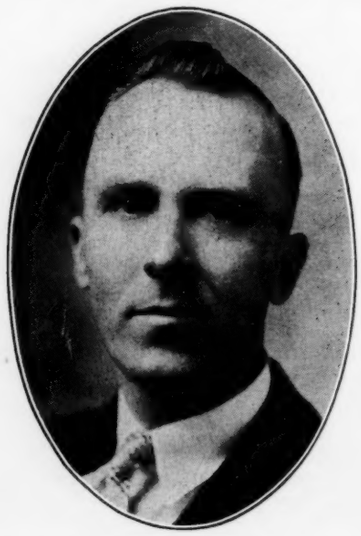
GENERAL PLANT MOTORS

1 to 100 H.P.	95% of all—225 Sec., Viscosity Engine Oil	Old Style—Ring Oiled
	Low Lime or Soda Soap Base Grease	Cup or Force Feed for Anti-Friction Bearings
100 to 500 H.P.	95% of all—225 Sec., Viscosity Engine Oil	Old Style—Ring Oiled.
	Low Lime or Soda Soap Base Grease	Cup or Force Feed for Anti-Friction Bearings

MAIN DRIVE MOTORS

500 to 8000 H.P.	150 to 225 Viscosity Oil—Some use regular turbine oils; others, regular engine oil.	Mill Drives—Force System with filters.

LINN O. MORROW,
Secretary, Philadelphia Section



JOHN B. LOONEY,
Secretary, Birmingham Section

A. J. WHITCOMB,
Secretary, Chicago Section

Discussion
Lubrication Papers

Presented at the Twenty-Seventh Annual A. I & S. E. E. Convention, Cleveland, Ohio, June 18, 1931

Papers presented

A Discussion Covering the Questionnaire Sent to the Iron & Steel Industry in Connection with Steel Mill Lubrication Practices, by the A. I. & S. E. E. Lubrication Engineering Committee.

"Crane Lubrication," by T. J. Flaherty, Electrical Superintendent, American Rolling Mills Company, Ashland, Ky.

"Lubrication of Electrical Apparatus Used in Steel Mills," by J. L. Brown, Mechanical Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

"Lubrication of Machine Tools," by J. H. Van Campen, Chief Engineer, Republic Steel Corporation, Youngstown District, Youngstown, Ohio.

"Lubrication of Turbo Generators," by J. L. Roberts, Assistant Installation Engineer, Turbine Department, General Electric Company, Schenectady, N. Y.

"Testing of Lubricants," by Frank L. Gray, Lubrication Engineer, Illinois Steel Company, Gary, Ind.

"Testing of Lubricants," by E. S. Glauch, Mechanical Engineer, Joseph Dixon Crucible Company, Jersey City, N. J.

Discussion Presented by

C. C. Pecu, Lubrication Engineer, Bethlehem Steel Company, Lackawanna, N. Y.

J. D. Donovan, Electrical & Mechanical Superintendent, Republic Steel Corporation, Massillon, Ohio.

G. W. Miller, President, American Lubricant Company, Buffalo, N. Y.

J. L. Brown, Mechanical Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

E. A. Matteson, Engineer, Great Lakes Steel Corporation, Ecorse, Mich.

J. L. Roof, Superintendent Blooming Mill, Republic Steel Corporation, Buffalo, N. Y.

T. E. Watson, Sales Engineer, Johnston & Bales Company, Cleveland, Ohio.

W. E. Daniels, Mechanical Foreman, Bethlehem Steel Company, Lackawanna, N. Y.

R. E. Brock, Chief Engineer, Spang Chalfant Company, Etna, Pa.

A. D. Adams, Assistant General Superintendent, Spang-Chalfant Company, Ambridge, Pa.

E. Gerber, Sales Engineer, National Carbon Company, Pittsburgh, Pa.

T. J. Flaherty, Electrical Superintendent, American Rolling Mills Company, Ashland, Ky.

W. F. Maurer, Chief Electrician, American Rolling Mills Company, Middletown, Ohio.

A. M. MacCutcheon, Vice President, Reliance Electric & Engineering Company, Cleveland, Ohio.

F. L. Gray, Lubrication Engineer, Illinois Steel Company Gary, Ind.

H. R. Reynolds, Fafnir Bearing Company, New Britain, Conn.

J. L. Roberts, Assistant Installation Engineer, Turbine Department, General Electric Company, Schenectady, N. Y.

H. E. Thompson, Lubrication Engineer, S. F. Bowser & Company, Cleveland, Ohio.

E. K. Ralston, Case School of Applied Science, Cleveland, Ohio.

C. C. Pecu: Gentlemen, it is said that life needs a crank to turn things over. Many of you fellows know me personally. In my own plant, while I try to be congenial and pleasant, and am, it is my object in life to let every man have his own way as long as he is doing as I think it should be done. But the outcome is, that it takes two of us to accomplish anything. The man who is on the job does his work, and if you can guide that man your way in a certain manner, you surely get results.

I really think that we steel men, the men sitting before us today, realize that the lubricating game is a real game. It is not one that takes a diplomat, but it takes a man who knows the machine. If you want to lubricate a machine properly, you must surely know the machine itself.

Of course, I am the youngest man as chairman, but I think I am the oldest man in years, and I have had a great deal of experience in lubrication dating back to 1909.

The men who are manufacturing lubricants today are more keen than ever. The lubricating devices have brought out better lubricants, and at no time in the history of the lubricating game has it been more pronounced than now. We are all functioning on one point only—better greases, better devices, and more able men to apply the lubricants and use the devices. That is the main object of this division, to assist wherever possible, and I think as we get together from time to time, as we come to know each other, we will become personal friends, and we can "swap" our little bits of knowledge from one to another, and in doing that we have accomplished the greatest results possible.

On June 15, 1909, I was taken out of the mechanical forces and put on this work. After erecting machinery for twenty years, I was put in a rolling mill. I didn't know any more about it then than the ordinary steam engineer. I had followed the steam engine game all the days of my life, and consequently I did know how to take care of the steam

Papers by the Messrs. Brown, Van Campen, Gray and Lubrication Questionnaire Discussion appeared in June 1931 issue of Iron and Steel Engineer. Mr. Flaherty's paper appeared in July issue and Mr. Roberts paper in August issue.

engine. When I started to work, the main work was on the engine proposition. I centralized on that two years.

Then the matter came up about the rolling mill. I took it the easiest way possible, and that was to take a piece of machinery that we could easily handle. I took those and followed them along, until eventually we started from the engine to the mill pinion and the mill pinion to the roll housing, and expanded through the entire mill.

We men in the lubricating game today know that the improvements have exceeded our expectations. The manufacture of lubricants, the manufacture of devices, and the design of mills have gone further than we expected. Still there are many, many things that we can improve upon. The only way we can improve is by asking questions and answering questions in a friendly manner, giving advice the best we possibly can, knowing our advice may be thrown down, but at the same time it might help.

If you can get together with another man and argue a proposition, in a proper manner, you may not adopt one thing that man has said, but he will give you a line of thought. We, as an Association, put out a questionnaire to several plants in this country, and we received many answers. Those answers have been put in a form so we can get the highlights of the majority of steel plants and other plants in our country.

At this time, Mr. Little, our Secretary, will read them. While it is a resume, it is the actual facts as we received them from those questions. See page number 422.

I hope you will feel free to ask any questions, and I hope your questions will be answered. By questions and answers, we will get results. Otherwise the paper amounts to nothing. We must pick it apart. There are many things to be brought out here.

C. C. Pecu: Outside of the concluding paragraphs of this paper, it is absolutely and totally taken from the questionnaires that were put out. These suggestions and the different notes in this paper were from men from all parts of the United States who are in the rolling mill game.

J. D. Donovan: The paper was very interesting, and I think it is very timely .

There is only one thing I can't quite understand, and that is the testing, where you state in your report something about testing for application. Do you mean testing for different applications?

I do think the paper is timely, and I think we can benefit a lot by this section of the Association.

C. C. Pecu: Perhaps you people have noticed from your trade papers that the Timken Bearing Company has a machine on the market showing the pounds of pressure and the scuffing of the surface. We thought it might be, that they could tell us the pressure for the different applications of work, whether anti-friction bearing or whatever type it is. We thought the manufacturers of Greases should know what pressure and heat conditions it would stand during operation so you and I, as rolling mill men will not have to go through this investigation.

In other words, if I am free to say so—and I know every grease manufacturer will back me up in it—we have been in the experimental stage in lubricants. They have done the best they could with this proposition, There is hardly a grease in the United States that we haven't experimented along with a chemist from the laboratory. We had no other way to get it. But today if we know the pressure and know the heat conditions, an enormous quantity of our worry in our mills is done away with.

I am sure the grease manufacturer today will assist us a great deal.

G. W. Miller: With the increased use of automatic lubrication devices and the tendency toward the use of softer greases for roll neck lubrication, is it more desirable to use a soluble (soluble in water) grease similar to most of the harder roll neck greases which have been used in the past, or is it more desirable to use a completely insoluble grease?

From the grease-maker's standpoint, the soluble and insoluble greases are two distinctly different products and I would like to know from the steel man's viewpoint which is most desirable for his work. Knowing which type grease is preferred, it will enable the grease-maker to perfect that type to its highest efficiency.

C. C. Pecu: Mr. Miller, you being a grease maker. I would like to have somebody answer that question.

What we want—if I may answer, as no one else seems to do so, is not a massive film of grease, but a film that does not break down. Many people have a wrong idea as to what lubrication is. I want the film that doesn't break down, but I don't want a great, heavy film on a roll neck. If you are rolling a heavy section, you know very well you haven't got a film of .001 or .002 of an inch on that neck. If you did have, you wouldn't have a perfect section, because it would break through and the section would be uneven. You have to have that film that Steinmetz says is .0004.

I have had people come with me and say, "There is no film there." I would say, "Yes there is." On Sunday they would come in and say, "Isn't that a beautiful film?" They didn't realize that the Sunday film we saw after the mill was shut down was the film left there after the water had been shut off and the weight of the grease had fallen down onto the neck, and the neck was dry and had dragged the grease on it, leaving the film.

I have seen soluble greases working in many instances. I saw a soluble grease work in a plate mill at one time, where the bag hung over the neck and it was dripping on the surface. There was a good film on that neck, and the bearing did well, but it was a costly, trying proposition and yet some people use it today.

I think that nearly every mill operator has seen lubricating devices of every known type. I wouldn't care for a man who didn't have his own ideas which he would develop according to his own thought, taking a lead from what he hears from others. In my work I have developed grooves in bearings and changed them until I found the best condition possible.

In the blooming mill, I think it is the easiest thing we have in the entire plant to lubricate. I have the least trouble with them, and we are getting along fine, but when we come to the high speed, bar mills, skelp mills, and strip mills, we have another proposition entirely, and we have to guard ourselves, the same grooves we put into the bloom-

ing mill bearings won't last over night in the strip mill bearing.

I think every individual, every mechanical foreman, every lubricating engineer, all superintendents of the mills, should get together on this point and experiment to develop the best possible results.

I might as well bring out another thing. Many people have their own ideas as to greases. I am a soft grease man. I always have been since early life. I want lubrication from the time the roll starts, not after you develop friction and form a heat and then get lubrication.

I have been criticized by people because I was using such a soft grease. When we used a softer grease we had to go to the grease form. We had to have grease forms and such devices to hold our greases in position. Those grease forms today are nothing more or less than a scale guard in our mill, protecting our necks and supporting the grease on the neck.

You have to put the grease on so it will lay on the neck. The soft grease is the grease to do it.

J. L. Brown: Could I ask you to give us a little more light on the remark made in the first paragraph, beginning on the right side of page 265, down about the middle of the paragraph, where it says: "Again if a bearing has been hot it has without a doubt a skin of glassy hard metal that will not assist in keeping the proper film."

C. C. Pecu: While it probably doesn't sound right, that is true. A burned babbitt surface is glassy and will not hold a film. It is a difficult thing to hold any lubricant on that bearing.

Many times you have seen a bright streak on the neck, a very bright polished surface. Along beside it you will see a dark film of grease. That bright surface, without a doubt, is a high spot in the bearing surface and it is the high spot where the pressures come.

A man came to me in one of our large mills and said, "I don't understand why that grease film should break at that point and the rest have so much grease on it."

I said, "That is the only place that neck is hitting the bearing." "If that neck were hitting the bearing all over, you wouldn't have that heavy film of grease."

One of the most pertinent things I read in this questionnaire was the Babbitting of bearings. If you do not get it absolutely true so your neck will conform, you will have the bright spots and the heavy grease film in other parts.

E. A. Matteson: I wonder if there is any information available as to the comparison between using water and grease or some other method of lubrication on bakelite bearings.

C. C. Pecu: This gentleman wants to know if in using a bakelite bearing, there has been experiments showing the difference between water and grease lubricants as to the wear of the bearings. I would like to have the people in this audience tell us where these bearings are used and what service they are getting?

I want to ask a question, in answer to that. If water is a lubricant, and we can see that a grease is a better lubricant than an oil, why wouldn't the bearing last longer with the grease? You can take a bearing and put grease on it and get better results than with water. You will also not have that trouble in the morning. If your mill is belt-driven and you have wood bearings, and it is a high speed mill, without a doubt you will have a great jar in the pull of the belt in the morning if you do not swab your neck at night before you shut down.

J. L. Roof: In using pressure systems is there a tendency toward the elimination of bronze as bearings?

T. E. Watson: As a representative of one of the manufacturers of lubricating equipment, we are in favor of continuing bronze in steel mill equipment.

C. C. Pecu: I am going to ask Mr. Daniels of the Bethlehem Steel Company, Lackawanna, N. Y., to tell us in a few words what he thinks of bronze metals in roll neck bearings. I am going to ask him to give us his experience.

William Daniels: We have found in our experimentation that it depends mostly on the bearing, the conditions the bearing is under, whether you can do away with the bronze strip. Some simply will not stand up without bronze at all.

C. C. Pecu: Mr. Daniels has spent much time experimenting on this. He has a mill in which he can do it. He has convinced himself that brass is no good, and later on he has again convinced himself that he does need brass.

I can tell you that in all our blooming mills except one we have nothing but the bronze collar strip, and no brass at all in the body of the bearings, and are getting better life than ever before. Why? First we put the brass in to stand the heat and the wear, because the bearing was not properly lubricated, and today we are lubricating properly and do not have the wear and the heat caused by the pressure on the brass.

If I give you my experience, just remember that is mine. I would like to have your criticism. I am here to learn as well as to give my little bit.

Are there any other questions you would like to ask? There is just one question you people have not asked, and that is: What is the best lubricant to use under certain pressures? Maybe we don't want to bring that up today, but there will be a day in October when you will have this, and the manufacturers of lubricants will tell us that, and they have to be wise men, because we are going to tell them whether they are right or wrong.

R. E. Brock: I would like to know if you have had any experience with the completely enclosed bearing principally using babbitt and automatically lubricated.

C. C. Pecu: Do you mean a sleeve bearing?

R. E. Brock: Yes, fully enclosed, or any other bearing. We have had some little experience with that, and we have had wonderful results. I would like to know if anyone else has had experience.

C. C. Pecu: Mr. Adams, will you just give us a word as to the results on the full collar bearing?

A. D. Adams: We have been experimenting on sleeve type bearings for about 5 years, semi-automatic lubrication prior to November of 1928 and full automatic since. Pinion bearings of the lead base

babbitted sleeve type run 4 to 5 times as long as the split bearings.

A 28" Sizing Mill having a 12" Roll neck, run from December of 1927 to June of 1931 before any of the bronze sleeve type bearings were changed. One half million tons of steel were rolled in that time.

On our 34" Return Rolling Mill on the top roll we installed a 22" sleeve type lead base babbitted bearing and rolled 960 pieces of 7" pipe in 8 hours, the water was eliminated for the first time on this mill, and the temperature was not over 120° F. at any time. The long life of this type bearing secured with automatic lubrication overcomes the argument for the adjusting or take up feature; scale is prevented from entering the bearing, the fillets are kept clean of scale, and the scoring and heat cracks on the necks are prevented.

C. C. Pecu: Mr. Flaherty has brought out some information for every plant, irrespective of whether it is in the sheet mill or any kind of mill. If there are any questions you would like to ask Mr. Flaherty, I want you to feel free to ask them.

Or has someone in the room some thought on this subject so they can give us some idea of the improvements they added to their cranes?

E. Gerber: I would like to ask Mr. Flaherty what is the design of his spring, and also the pounds pressure for different sized axles. That is, figuring it by the diameter and length of the bearings, what pressure will his spring exert against that grease carrier?

There is another question I would like to ask, as to whether or not he has had any experience in the lubricating of bridge motors and armature bearings with soft greases, as in high speed cranes where the oil has a tendency to splash when the cranes back very suddenly and spill down around the bridge motor.

T. J. Flaherty: In the first place, in answer to the first question, the type of apparatus we use in our M.C.B. bearings the boys call a rat trap. It is a flat plate with a couple of stud bolts on the flat side of plate. The cellar boxes are drilled down through the bottom and the springs applied underneath the plate. The bolts when they appear under the cellar box act as an indicator to show when your grease is low in your cellar box. The pressure is about eight pounds per square inch on about a five or six inch journal.

C. C. Pecu: The other question was if you were using any grease on bridge motors and armature bearings.

T. J. Flaherty: We have tried it on armature bearings without much success except on roller bearings. However, we have tried it on the back axle bearings and it has been very successful.

W. F. Maurer: I was down in Mr. Flaherty's place one day. The "rat trap", as he calls it, is very successful. We took it up to our place and tried it out. We do eliminate the grease drippage.

T. E. Watson: We have found the interest in sheet mills is considerably more than in some other mills because of the ability to measure a certain amount of grease at each bearing. That seems to make a hit particularly at sheet mills while there is not very much interest in the blooming mill.

In regard to this spring device that Mr. Flaherty speaks of, I learned of that in another place. I am not sure it was the same thing, but it accomplished about the same results and is giving very good results.

G. W. Miller: On armature bearings of motors on cranes, I might bring out this point—that in the textile industry, on high speed bearings, it is necessary to use a lubricant that will not splash or drip off. Therefore, they manufacture a type of liquid grease. In other words, it is an oil which has had capillary action killed so that a drop of this oil when dropped on a piece of glass will stay where you put it; it won't run off like oil.

I thought that might be interesting in lubricating these bearings. In other words, it wouldn't splash like oil.

T. J. Flaherty: We have tried almost every type of oil or grease. The trouble we have had is when it comes to the enamel plant, the enamel won't stick to the sheet.

G. W. Miller: This is very true. What I meant was, after the oil gets on the sheet, the damage is done. The idea is to keep the oil from the sheet. An oil prepared in this way will not drip. There is a wide difference between treated oil and non-treated oil.

T. J. Flaherty: Of course, our object is to keep the oil entirely off, if possible.

G. W. Miller: In using that type of lubricant you would have 75 per cent less chance of the oil forcing out of your bearing and dripping off than when you use straight electric motor oil.

E. Gerber: May I ask a question? Mr. Miller speaks of grease that is not going to drip. What temperature does he figure? How is he going to keep excess grease from running out, especially in change of temperature during spring or fall?

G. W. Miller: Of course, you can't overcome the human element or a mechanical defect with a lubricant. We have all tried to do it. Sometime you succeed and sometime you do not. You naturally have to watch that you do not fill your bearing too full, whether using oil or grease.

In regard to temperature, which we all know speaking of viscosity or body that at room temperature there will be one body or one viscosity and as the heat increases, your viscosity curve will change and the oil or grease becomes thinner. Where a grease is used, if the proper type of mineral oil and base is used to start with, the desired melting point and consistency can be obtained for a wide range of atmospheric temperature changes. Where a straight oil is used and difficulty is encountered from dripping, we have overcome this difficulty by the use of a fluid grease in place of the straight oil.

In the manufacture of this fluid grease the capillary attraction of the oil is decreased to a minimum, which prevents creeping out of a bearing and also dripping.

Further, this process so changes the nature of the straight oil that a very flat viscosity curve is obtained and when high temperature is reached, they affect

the fluid grease so little that it naturally tends to eliminate creeping and dripping.

As this fluid grease can be manufactured from very low cold test oils, perfect lubrication can be had in very cold weather and you will find that the lubricant will still maintain a good body in warm weather.

This type lubricant can be successfully used in plain, anti-friction or ring oiled bearings.

R. E. Brock: I would like to ask if any of the members have had much experience with bronze bearings with so-called wood plugs in them that are supposed to automatically supply the bearing through the wood plug. It has been claimed that this oil will percolate through the shaft by capillary attraction, and lubricate the bearing with a very small amount of oil. It has been claimed that it does away with practically all dripping.

I haven't had any experience with it, but it sounds good. I wonder if anybody has had any experience with that type of bearing.

T. J. Flaherty: We have some on test right now on hoist sheave block. However, we haven't had any report on them. The C. & O. railroad has that in practice and is getting very good results out of it.

J. D. Donovan: After hearing Mr. Flaherty's paper, I can sympathize with him or anyone else who is in the sheet mill business, in regard to taking the oil out of the sheets. I can also sympathize with the chairman when he decides on a Sunday morning to visit the mill with a new straw hat on.

We started a little campaign a few years ago to put wipers on to catch all the grease. We had two things in mind when we started out. It wasn't simply the oil. It was also graphite mixed with oil.

We installed wipers to keep our girders clean from the safety standpoint as well as from the lubricating standpoint. We don't use anything expensive. Usually we can get enough of burlap or something like that to put on. That has been very successful, more so than I thought when I started out. Those wipers are on the regular inspection report and just as important as any other part of it.

C. C. Pecu: There was one thing that I thought was very pertinent. That is the overflowing of the grease. In other words, the novice, the man who does not realize that filling his bearing full of grease will create a frictional heat and cause him trouble. Is that right, Mr. Brown?

J. L. Brown: Yes. When we let the motor go out of the factory, we have no control over it any more. We don't know who is going to handle it, and in order to take care of everybody who will handle it, as far as possible, we think that the overflow and the surplus reservoir is an advantage.

C. C. Pecu: I think it is a great advancement. The question has been in our plant: Who is going to lubricate these bearings? Are we going to fill them full and destroy them?

One time I saw a man fill a bearing, thinking he was doing the proper thing, but he had not been guided right and wrecked the bearing inside of fifteen minutes, due to frictional heat. We found it was really our fault, because the man did not understand. Today in our plant we do not allow every Tom, Dick or Harry to have anything to do with the anti-friction bearing proposition. The electrical foreman looks after that, and we have certain stated times it should be lubricated, and tabulated forms showing when it was lubricated and how often.

A. M. MacCutcheon: I am greatly interested in Mr. Brown's paper. I think one of the troubles we have had with anti-friction bearings is that when we started to consider them and use them there were some that thought they were a cure for all evils.

I well remember the 1919 or the 1920 convention —when we first began to talk about the use of anti-friction bearings, and I had the pleasure of presenting a paper. Reference to that paper will show that I pointed out that we should not consider that anti-friction bearings were a cure for every evil. We didn't expect they would be, and they haven't been. I think the pendulum swings in this case and in many other cases too strongly. I have heard statements made in the last five years that all that is necessary is to install ball bearings and no further attention will be required. This is wrong.

There are well authenticated cases where anti-friction bearings have run from four to five years without any attention; those are only rare cases that are interesting. They simply point the finger toward a type of bearing that is very good but is not a cure for all evils.

As Mr. Brown has pointed out, I think the proper lubrication of the anti-friction bearing is the great question today. We have tested actually hundreds of greases I think, and we can't say yet we have found what we consider a perfect grease for all conditions.

I don't wish to criticize the grease people, as they are working very hard. But we do find variation in the same grade of grease bought from the same supply. I know that some of the prominent grease companies are concentrating on this problem.

We have had difficulty with greases which have been thoroughly tested as A grade and seemed to be entirely proof against the trouble I will mention, and yet those same greases that had been so thoroughly tested developed this trouble. A motor that is put in stock may stay in stock for six months or a year, or a year and a half or even two years, because we all appreciate that when motors are put into stock we don't go back and pick as the first motor that is sold the first one made. The first motor shipped is likely to be the last one made. So it is not uncommon to have motors in stock that may be a year and a half or two years old, and the grease may harden.

Oxidation of the grease is probably the cause of the hardening. Motors that could easily be spun on test with the fingers, motors 10, 15, 20, 25 or 50 horsepower, couldn't be turned over at all when taken out of stock for shipment. Upon taking them apart, it was found that the grease had oxidized and a very bad condition had resulted.

As a result of that experience, we have found it necessary to always check a motor coming out of stock to be sure that the lubricant is still in good condition.

We have had the opportunity of making a great many tests on the oxidation of grease of various kinds. The test takes a good while. The condition doesn't usually show up under three months. It may not show up for a year, and yet eventually the condition may appear.

The condition isn't quite as serious as we at first thought it was. We have taken motors that could not be turned over by hand; put power on them; run them, and then taken them apart. The grease seemed to be in pretty fair condition. The surface of the grease was oxidized. When thoroughly mixed the quality was fair.

I have recently heard from one of the steel mills of a grease that apparently gives good results, and we are now testing it in our laboratory. It is a graphite grease.

For years there has been a prejudice against graphite grease, but as the manufacturers of this graphite grease tell us, and it sounds logical, there is no trouble in using a graphite grease if it is artificial graphite and not natural graphite.

I will be glad to report the results of our experience at one of the future meetings on lubricants. The test has been running about a month and a half. One of the most prominent mills told me about it, a mill with a very high standard of operation and a very thorough method of investigation. I understand they have used the grease for over a year, and if I recall correctly, the introduction of this grease into a certain set of bearings on a certain motor resulted in the reduction of the temperature to the amount of eighteen degrees.

In closing, I think it is only fair to the anti-friction bearing to repeat what I said earlier today and what I said around 1919 or 1920. Do not let the pendulum swing too far either way. A good engineering view takes one down the middle of the path. There are very considerable advantages in an anti-friction bearing and the same can be said of an oil bearing. I believe one of the greatest services the anti-friction bearing consideration has rendered to the industry is to have forced a very thorough study of oil lubricating problems.

I think that we should look on the anti-friction bearing problem now principally centering around the lubricant. I know that the lubricating people have worked increasingly over the last seven or eight years and are doing more today than they have done at any time in the past, and that a thoroughly satisfactory grease in all ways is the thing that we need more than anything else.

And then we also should remember that since it has taken twenty-five or thirty-five years to get a thorough understanding of the problems on lubrication of sleeve bearings—and certainly Mr. Brown has a very fine design—we ought to give the anti-friction bearing people and the grease people, when grease is used in anti-friction bearings, plenty of time and not condemn them on the experiences that we are having, which are not so satisfactory, any more than we condemned the sleeve bearing people. We should keep struggling to get an improvement in each and use each in its proper place.

F. L. Gray: Speaking of the grease in the bearing oxidizing, we have not only had that same experience but we have also had the experience that sometimes the oil will settle out of the grease, and in case of leakage it will get away. It is very necessary that the equipment that is in stock for a while should be inspected before the apparatus is put into service.

I have nothing further, Mr. Chairman.

H. R. Reynolds: We have adopted the practice of packing our bearings in pure petrolatum, eliminating all possibility of the hardening of the grease. It has cost us thousands of dollars. The trouble seems to be that the ordinary greases, if put into a unit and given a trial run, get a certain amount of aeration, which in many cases promotes oxidation. The units are then put on a shelf for an indefinite time, and afterwards sold, and then the trouble from hardened grease is reported.

As a result of that and the tests we have made, we have adopted the neutral element, petrolatum, because not only in itself does it not change, but its mixing with other greases doesn't cause the trouble we have sometimes noticed.

I believe if in packing motor bearings the motor manufacturers would initially use something like petrolatum, they would also eliminate a lot of future trouble, because it is very simple to do as we do, instruct the user to lubricate when he puts his new motor into service.

We have found that if the temperature is constant, the bearings will run for a year with initial application of petrolatum, and all we put in, is what little sticks to the bearings when we dip it into the hot material. We heat to a melting point. We have run bearings in our laboratory for a year and taken them out nicely lubricated.

Mr. Brown's housings are beautifully designed and would permit the use of petrolatum as a continuous lubricant. Bearings simply need to be kept moist with lubricant. Speeds develop temperature; that has been pretty well noted. The small amount that would stick in the housing of Mr. Brown's type would not be objectionable, if you used a material that is free from internal friction, as petrolatum. Some of the woodworking people have for years used similar types of housing where the greases were applied on one side of the bearing and of necessity worked through the bearing and collected in a well underneath. And their speeds, of course, you know run rather high. One application which I am thinking of uses a bearing about six inches outside diameter, running 6500. They successfully use about a No. 2 grease, which has a consistency similar to petrolatum, and feed it directly through the bearing, applying it occasionally. When the temperature is developed, then they know enough to open the plug at the bottom of the drain and drain off the surplus grease. Everything is serene and on they go.

C. C. Pecu: Mr. Roberts has brought out several things that, while many of us are familiar with the turbine lubrication and turbine operation, are very pertinent, such as the mode of babbitting their bearings. The idea of the centrifugal force in babbitting was another point. Mr. Roberts, what speeds do they put these bearings up to when being babbitted?

J. L. Roberts: That all depends on the size of the bearings, but usually the larger bearings they do not have to spin over 300 or 400 r.p.m. You can take a pail of water and whirl it around your head at a very slow rate, but the higher the speed that we spin these at, the more dense will be the metal. We certainly struck an average of densities, and we found it gave us a homogeneous mass, and that is as high as we cared to go.

C. C. Pecu: In the babbitt method in these bearings, was it high tin base, or what was it?

J. L. Roberts: It is tin, copper and antimony.

C. C. Pecu: Regular tin base metal.

J. L. Roberts: Yes, about 83.3.

C .C. Pecu: Are there any other questions to be asked?

On the process of filtering oil used on the ordinary turbine, I think we have a man in the audience who can enlarge on the problem, and that is Mr. H. E. Thompson. Will Mr. Thompson tell us about the new developments? We have to take every opportunity to get all we can. Mr. Thompson is here to do us a favor. I am sure he will speak on that subject, connected as he is with the advanced form of filtering of turbine oil.

H. E. Thompson: The continuous removal of contamination of turbine oils is not a new one. The Prime Movers Committee of the National Electric Light Association are quoted from their report of 1922, Page 328 as follows:

"The efforts of the users of the (turbine) oil should be directed toward the prevention of the contamination of the oil in storage and in the lubricating system, and to provide means for the continuous removal of the sludge and contaminating agents from the oil while in service."

Experience has proven that oxygen is the worst destructive agent in turbine oils and every means should be used to prevent aeration of the oils by avoiding thin sprays or films splashing of oil in bearings, etc. Instances are known where tests of oil vapors from bearings showed the acidity was ten times as great as the acidity in the main body of oil in the turbine reservoir.

The advantage of a By-Pass Filtering System using a gravity precipitation method lies in the fact that the oil is never violently agitated, thereby avoiding any further aeration than that which the oil is subjected to in the turbine itself.

The system consists essentially of the Oil Filter and Positive Type Circulating Pump and a Vented Sight Overflow Fitting which is located at the prescribed oil level of the turbine and through which the oil is continuously by-passed to the filter at a rate of approximately 20% of the amount in the turbine reservoir per hour. This rate of filtration has been found to invariably produce best results.

Purity

Naturally, the oil selected should be received in the highest degree of purity and be absolutely without free carbon, foreign matter such as particles of metal, dust, dirt, etc. (which contribute with oxidation in causing sludge) or water. Throughout its storage and use, the nearer it can be kept to the condition in which it is received, the more favorable may the condition of use be considered.

Emulsion

Air and water agitated in oil form a mixture or emulsion consisting of non-lubricating globules disseminated in the body of the oil. This contamination is brought about in various ways—through the accumulation or leakage of water from packing glands or seals, from oil water cooler, or from water-jacketing coils of bearings—also from steam condensation and from air breathing in oil tanks, or where the oil comes in contact with the atmosphere collecting particles of dust or other impurities in suspension in the air. If these impurities are removed as fast as formed emulsion does not occur.

Oxidation

The accumulation of air and water entrapped in the oil form a mixture, which, under the influence of heat and agitation tends to aid in oxidizing the oil coagulating certain of its constituents.

Sludging

Sludge forms readily in an emulsified oil. It is the product of impurities and oxidation in the form of a viscous and thick coagulate, retaining most other solid matter which accidentally come in contact with the oil. This sludge adheres to all surfaces, obstructing passages and channels, reduces the lubricating properties of the oil as well as its cooling effect, and necessitates frequent cleaning of the system. If emulsion is prevented sludging will be greatly lessened.

Deterioration

Under the combined influence of the above agents, the oil has a tendency to deteriorate and quickly lose its lubricating properties, resulting in serious troubles in the operation of the turbine.

Given the proper oil and a clean circulation system, there should be no appreciable deterioration of the turbine oil even after years of continuous service. Emulsion is caused by water and air accumulating in the oiling system. By continuously removing these, there is little or no chance for emulsion or the formation of sludge in a Continuous By-Pass System. The purification of the whole oil charge is so frequent that there should be no appreciable amount of sludge or muck deposited in the turbine oil reservoir, in the oil piping or in the oil cooler coils. Therefore frequent cleaning of the coils is unnecessary and their heat conductivity is unimpaired.

Our By-Pass Oil Filtering Systems are in use by many of the large and prominent Public Utilities in the country such as Phoenix Utility Company, Milwaukee Railway & Light Company, Hell Gate, South Meadows, Springdale, Hauto, Colfax, Virginia Railway & Power, Cleveland Electric Illuminating Company (sixteen systems at Avon, E-70 Street and Ashtabula stations) and also by many of the large Steel Plants throughout the country.

In a large steel plant in Cleveland five turbines served by a Continuous By-Pass System have been operated over a period of twelve years without completely renewing the whole oil charge at any single period of time. The engineer reports that over a period of eight years his "make-up" oil added to the system only amounted to one per cent of the total oil charge in the five turbines per month or, in other words, at the end of eight years he had just about replaced the original batch of oil. At all times during this period careful tests showed the oil to be in practically as good a condition as when new. In another steel plant prior to installation of one of these systems for a small turbine, sludge had formed in a "coke-like" mass at the oil level in the reservoir and at the cooler causing the oil temperature and bearing temperatures to rise to an alarming degree. After about seven years of operation no similar formation of such sludge has been observed at the oil

level in the turbine reservoir and bearing temperatures have been normal.

In recent years there has been a trend of some, not a few, engineers to elaborate somewhat on the above system by using what is generally known as a Combination By-Pass Batch procedure whereby two complete oil charges are available. One charge is in use while the idle charge is stored in a two-compartment tank, cooled, precipitated thoroughly then filtered. It is then delivered to the turbine, from which the oil has previously been drawn to the other compartment, and is again circulated continuously through the filter as above described.

Where several turbines are involved only one two-compartment precipitation and cooling tank is necessary.

C. C. Pecu: Are there any questions you would like to ask Mr. Roberts on the operation of turbines, or is there anything that has come up in your practice on which you would like to know more about?

J. L. Roberts: There is one question I would like to ask. I am not very familiar with steel mill lubrication, but I was wondering how you take care of the losses in your bearings.

It does not seem to make very much difference about the viscosity of an oil or the grease or any lubricant that you may use, if you do not take care of the temperature. If you maintain control of the temperature in the bearing, you may use either cylinder oil—I might say having a gravity of 600 and bring the temperature up high enough—or use a very light oil at a lower temperature. They will all come to the same viscosity.

You may think you have a heavier viscosity by using a heavier grade of oil or grease, and if you do not remove the heat from the point of contact, it seems to me that that viscosity is going to come to a point where it simply will not support the film.

As I pointed out here, as the temperature of the lubricant increases the viscosity decreases, and also the supporting power of it decreases, and those things are very important to us, especially where we have high-speed lubrication. It is very important that we do have correct lubrication, because a bearing failure to us is quite a serious matter and amounts to a good many thousand dollars.

Nearly all the discussion I heard this morning on steel mill lubrication was on grease. I was wondering why oil, maintaining the proper viscosity would not be just as good and could not the losses be taken care of, because by using a fluid you can remove the losses and control them.

C. C. Pecu: Will someone in the room answer Mr. Roberts?

I am sorry, Mr. Roberts. I don't think anybody would want to answer you.

J. L. Roberts: I think probably there are some machine design men in here.

C. C. Pecu: That would be fine, but you want to remember that when we are rolling steel we are doing everything we can, and it is lucky that we do well at all, under the conditions we have to work. Our sections are varied, and we are allowed just so much tolerance. You people cannot allow anything in your practice; you have to keep it right down to the minimum. Here we have to take the different viscosities. We can't use oils in many cases on roll necks, due to the flooding of water. On pinions and such machinery, we want to keep the water down as much as we can. It is an entirely different proposition.

You know the rolling mill practice pretty well, don't you?

J. L. Roberts: Not very well. I know about what their duties are, yes.

C. C. Pecu: The best way I can answer you is to tell you to go over and spend a day with me, and I will show you what we are up against as rolling mill men. There are lots of things that I am sure we would enjoy talking about; I could help you some, and you could help me greatly.

J. L. Roberts: We have high temperatures to deal with. We are using 750 or 700 degrees steam, and on a space where we have about 18 inches, we are reducing that to a temperature around 140 degrees. We have temperature problems too. We also have the water.

C. C. Pecu: It is a very difficult proposition. I appreciate that. The oil has to be a much higher quality than we are able to use in the rough work in the steel mill practice. You have to have your cooling effect. You brought out something that I never heard before, something that is worth while for every man to know.

If we could have a chart, putting it into a power house, showing the losses due to the decrease of viscosity and change of temperature, it would not only make money for us—all the operators along the line—but make the man who is operating more keen to do his job.

You know how it is in the power plant. For instance, take a public service corporation furnishing electricity. They have a way of doing things and they are practically always done right. Their coolers are cleaned, and cleaned at a stated time, and they do not allow them to run any longer than that time, but in steel mill practice lots of times we slip.

That is what struck me more than anything else. Are we in our own department, my own plant, looking after the coolers as we should? That is what I wondered after you told me the losses we are running up against. I think that is one thing every man should think of. Not only the changes of viscosity of the oil and the friction losses and such things as that occur, but we are decreasing and destroying the value of the oil. The acid conditions cause sludging during that time, and we are not only building up losses in one way, but we are running into dangers in another way.

E. K. Ralston: May I suggest perhaps an answer to Mr. Roberts' question.

I believe we have a little different case in the case of a high speed turbogenerator bearing and say a cold roll machine bearing. That is, the largest difference is the fact that they are turning at greatly different speeds. In the case of one shaft in a bearing turning slowly, we have I think what is normally called boundary lubrication; that is, in that case the shaft isn't turning fast enough to draw in

sufficient oil into the space between the shaft and the bearing to support the shaft so that there is no metal to metal contact between the shaft and bearing.

In the case of a high-speed turbogenerator shaft and its bearings, due to the viscosity of the oil and the high speed of the shaft itself, it will actually draw in enough oil so that when the shaft is turning fast enough it will actually be supported on the oil itself. I believe you find that underneath the center part of the shaft the pressure is very high, probably a good many thousand pounds per square inch. It will be lower at the ends and at the sides. In this case, the weight of the shaft and the rotor is all actually supported on the oil, and there is always a thin film of oil between the shaft and the bearing.

In the case of slower speed bearings the shaft won't be turning fast enough to draw in sufficient oil to do that. In case we should try to use an oil with a heavy viscosity to lubricate the roll machine, the rougher parts of the shaft which you could easily enough see with a microscope—because, of course, we can't machine them perfectly smooth—will touch each other.

In that case it has been found it is necessary to have an oil or grease tallow with high animal fat content, so that we can have good lubrication, for some reason or other. I don't know just why that is.

There are two distinctly different types of action in these two cases. That is the reason; if we could run a cold roll machine bearing fast enough then, we could use an oil to lubricate the thing, but inasmuch as some of those bearings are run slowly, due to the action of the shaft it won't draw in sufficient oil and not drawing in enough oil we have to use a different type of oil or grease to lubricate them.

J. L. Roberts: That is just our trouble. In the paper I said that the friction within the oil film varies inversely within certain limits, approximately one-third power of the diameter or the rate it is being sheared.

E. K. Ralston: When we are running slowly, there is no way of forcing this oil in. The only way the oil is actually dragged through that bearing is due to the viscosity of the oil and the rotation of the shaft. I am pretty sure it would be impossible to pump oil, in a large turbogenerator, into the bearing with a normal pump that would pump 200 or 300 pounds pressure underneath the shaft at the point of high pressure in the bearing, because, due to the actual rotation of the shaft, causes the pressure to be built up so very high that you couldn't actually pump it in.

Now we couldn't pump the oil in there with the shaft turning that slow. The only way it will come in there is due to the rotation of the shaft itself. If you could get it in there, then that would work. But it can't get in there any other way.

C. C. Pecu: We are greatly indebted to Mr. Gray for this fine paper. It is worth while to take it home in the Iron and Steel Engineer and read it, so that any time in the future we can pick up the points that we would like to retain.

W. W. SPANAGEL,
Secretary, Cleveland Section

H. F. RAAB,
Secretary, Pittsburgh Section

*The Association of Iron and Steel Electrical Engineers' Suggestions to the Electrical Manufacturers in Connection with Standardized Symbols for Control Apparatus**

Since the publication of the article "Standardization of Steel Mill Magnetic Control" in the July 1930 issue of the Iron and Steel Engineer, meetings for the discussion of this subject have been held in Philadelphia, Chicago and Cleveland districts. Suggestions and comments have also been received from many of the large steel producing companies in these areas.

The minutes of the various section meetings as well as the comments submitted by the various individuals have been gone over and an attempt made to tabulate them into a form that will readily show what the opinions are on this subject.

While several suggestions were received regarding the standard symbols and nomenclature for control diagrams these have not been tabulated as it is felt that this question should be met by the control manufacturers, who should present their recommendations to this Association for its approval and comments.

TABULATION OF SUGGESTIONS

Size of Drawings

(a) Diagrams should be made larger than those furnished by the manufacturers at present. The The 16″x21″ size should be a little larger.

(b) Diagram should be large enough to accommodate all necessary symbols, etc., and of proper proportions to be used in Iron and Steel Engineer bulletins.

(c) Standard sheets made up in about three sizes.

(d) Diagram should only be large enough for the individual wires to be easily followed.

(e) Large enough to show all symbols and connections clearly.

(f) Diagram should be made on a larger scale than usual practice so that field men can mark colors on control cables, numbers, etc., on same to help them in connecting up without obliterating the drawing.

Information and data to be included on diagram.

(a) Elementary wiring of both control and main circuit to be on same sheet as main wiring diagram.

(b) Elementary wiring of both control and main circuit to be on same sheet as main wiring diagram also resistance diagram and values in a tabulated form.

(c) A complete key to all symbols used in making up the diagrams, particularly symbols of time delay relays, load relays, photo cells, tubes, etc., should be included on diagram. Also due to increased use of photo cells and tubes, manufacturers should be very definite in their markings of panel wiring, showing the actual operation of the photo cell or tube even to the extent of a written description of the operation of the equipment.

(d) External resistors with shunt coils or relays should be marked plainly as to ohmic value and current carrying capacity.

(e) Drawings, diagrams, etc., to show voltage of respective circuits, special mention to be made if power and control circuit voltages differ, such as a 440 volt power circuit and a 110 volt control circuit.

(f) Diagrams to be complete with main diagram, main and control schematic, or across the line diagram, sequence table, and tabulated data as to the resistor requirements for the particular application.

(g) Diagram should show all symbols and connections clearly, the resistance diagram, master controller and elementary diagram should be shown on same sheet. In many cases where sequence of operation is not clear an explanatory note would be a big help. All resistance values of both power and control resistors should be marked on the print.

(h) Diagram should have on the same sheet an elementary diagram of power and control circuits to give an idea of the operation of the control. Resistance diagram should be included.

Should wiring on panels be shown front or rear view?

A number of replies, including a meeting at Chicago and Cleveland specify rear view.

In a meeting at Cleveland the engineers recommend that "all wiring diagrams to be front or rear view depending on the size of the controller. In many cases small controllers are front rather than rear connected."

Distinction between power and control wires.

A number of replies including meetings held at Chicago and Cleveland agree that heavier lines should be used for Power circuit so that it may be readily distinguished from the control circuit. These lines indicating power circuits to be heavier than those now used by the various manufacturers.

Method of laying out and marking lines representing control and power circuits.

(a) All control wires should be numbered.

* Presented at the Twenty-Seventh Annual A. I. & S. E. E. Convention, June 15, 1931, at Cleveland, Ohio.

(b) All wires should be properly marked.
(c) Control panels should be marked front and rear with the same symbols used to identify the control wiring and main circuit wiring.
(d) There should be a uniform method of marking control and power wiring.
(e) The arrangement of the apparatus on the wiring diagram should be the same as the arrangement of the equipment on the panel.
(f) Wiring should be placed on the board as arranged on the diagram.
(g) When wiring diagram is laid out in the manufacturers' engineering department they should be arranged with a minimum number of wire crosses.
(h) Lines on diagrams should follow as closely as possible the actual wiring on the back of the panel.

Method of indicating and marking interlocks.

(a) Interlocks to be preferably shown at the bottom of the switch with a definite standard symbol for indicating normally open and normally closed circuits.
(b) Interlocks shown beneath the main contactors simplify the wiring.
(c) Where the auxiliary contact is insulated from, but operated by the main contactor, it would be preferable to indicate the auxiliary contact below the main contact without attempting to show that it is operated by the main contactor.
(d) Interlocks should be shown at the bottom of the contactor and should be shown clearly whether normally open or normally closed.
(e) Interlocks should be shown in the exact physical relation to the main contactor, i.e. either normally open or normally closed when the contactor coil is de-energized.

Method of showing connections between panel and master controllers, motors, etc.

(a) All wires should be properly marked and all lines followed through conduit, piping, wiring to switches, etc., and marked at every junction in order that anyone reading diagram could follow the individual line from source to terminals.
(b) Location of terminal blocks should be standardized.
(c) Wires to be marked where they enter and leave conduit instead of showing wires running through conduit.
(d) All wiring from panel to limit switches, etc., should be grouped in the form of a cable.
(e) The showing of hoist limit switch connections has the following disadvantages. It complicates the wiring diagram. In plants that have a standard drawing it is unnecessary. It allows the manufacturers to make "trick connections" by changing the hoist limit switch wiring.

Miscellaneous suggestions.

(a) Definite symbols should be agreed upon by the manufacturers for normally open and normally closed contacts.
(b) Manufacturers to be more explicit in indicating part of contactors that are "alive" or current carrying.
(c) Manufacturers should take extreme care in marking boxes and shipments to customer. Manufacturer's name, location, customers and manufacturers order number, horsepower rating of drive, and if possible the name of the location on which control is to be used should be clearly marked on outside of boxes, etc.
(d) An attempt should be made to make master controllers of more uniform sizes.
(e) Use of group resistance units for making up accelerating resistors for different size motors.
(f) Symbols to be duplicate or commensurate with NEMA and AIEE.
(g) Standard symbols for a contactor should be shown rather than a pen picture of same.
(h) Terminal blocks should be mounted ½ way up on either side of panel.

Discussion

Presented at the Twenty-Seventh Annual A. I. & S. E. E., Convention, Cleveland, Ohio, June 15, 1931

Discussed by

J. J. Booth, Electrical Superintendent, National Tube Company, Gary, Ind.

F. D. Egan, Electrical Superintendent, Bethlehem Steel Company, Lackawanna, N. Y.

James Farrington, Electrical Superintendent, Wheeling Steel Corporation, Steubenville, Ohio.

F. O. Schnure, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.

W. E. Miller, Electrical Superintendent, Bethlehem Steel Company, Johnstown, Pa.

F. W. Cramer, Chief Electrical Engineer, Republic Steel Corporation, Youngstown, Ohio.

R. G. Widdows, Vice President, Electric Controller & Manufacturing Company, Cleveland, Ohio.

L. A. Watson, Chief Engineer, Clark Controller Company, Cleveland, Ohio.

H. L. Wilcox, Engineering Department, Electric Controller & Manufacturing Company, Cleveland, Ohio.

H. A. Winne, Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

N. L. Mortensen, Chief Engineer, Cutler-Hammer, Inc., Milwaukee, Wis.

J. J. Booth: I would like to make a few remarks, before going into the discussion of the control system, in regard to what our President has already said along the line of this being an economical period.

Right now we are going through a more or less trying time. Our Association of Iron and Steel Electrical Engineers today is being looked upon more and more by the larger executives of our companies over the United States with the idea that we will produce. I think it behooves each and every one of

us, whether we are active members in the Association or associate members, or whether or not we are on the lubricating committee or the combustion committee or the electrical committee, to exert all our efforts to try to produce more along the lines of economy and efficiency.

Our Chairman has told you that I have had something to do with the question of symbols on control. I wish he had gone a little further, because, gentlemen, this is not my story, technically speaking, Mr. Angel, Electrical Department, Sparrows Point, Maryland was chairman of the Committee on Symbols. Mr. Angel, who I believe is no longer with the Bethlehem Company but is in Russia and Mr. Schnure, have done the bulk of the work in connection with this particular program.

I will say that I helped them out, as far as the Chicago Section was concerned, on one meeting, and also here at Cleveland.

There is one other point; that is resistors. Several members have had an idea that if we would make three or four different sizes of resistor boxes or resistor units and standardize on them and work up the other ratings from that particular standard by multiplication of boxes, we would be much better off in the end from the standpoint of first cost, from keeping the resistors straight in the field, from the standpoint of general maintenance and upkeep and the amount of money involved in spares.

I might say that we have with us one man this morning who has gone into that particular point or phase, and he was kind enough to send to our Association a number of prints showing the setup. I will ask him, before the meeting is adjourned this morning, to make a few comments. That is Mr. Egan.

F. D. Egan: The first thing we do in the standardization of a resistance bank is to standardize the mechanical arrangement and size of mounting. All banks are alike. We number the banks 1, 3, 5, 7 and 9, which about covers 90% of the banks we use in the plants.

In addition we paint the frames of these banks a distinguishing color, which is standardized. A motor inspector in one of the mills, on burning out a resistance bank that has a white frame, if he has a white bank available simply replaces it, or he can 'phone the shop for a white bank or go to an adjacent mill to find a white bank. It always has the same resistance and the same carrying capacity so it is very simple to locate the correct bank and saves considerable time.

In buying our control we do not buy the resistance with the control. We buy the control panel and ask the manufacturer to specify the resistance layout per step and its current carrying capacity, and then we adapt our standard banks to their layout.

In some cases I would say we have to put in more resistance than would be necessary had the manufacturer used his standards, but when buying control from two or three companies, you would have a number of sizes of grids, a number of sizes of banks, and in a lot of cases two or three sizes of grids in the same bank or frame. We feel we have materially reduced our costs, and we know we have materially improved our operating conditions by this standardization.

The original bank was laid out with cast grid resistance and we have since worked out the same standard banks using alloyed ribbon, which has worked very well.

The banks that we are using on the mill resistance work are Numbers 1, 3, 5, 7 and 9 with a continuous carrying capacity at 300 deg. C as follows: No. 1 bank is 120 amps.; No. 3, 70 amps.; No. 5, 60 amps.; No. 7, 48 amps., and 15 amps on No. 9. The total ohmic value is .35 ohms on No. 1, .78 ohms on No. 3, 1.40 ohms on No. 5, 2.48 ohms on No. 7, 18 ohms on No. 9. The frames are colored red, white, blue, black, red and white.

This one sheet fig. (1) on resistance value is carried by all the motor inspectors. It covers the current carrying capacity and the ohmic value for all the banks employed on the various drives.

James Farrington: I am certainly in sympathy with this work. I tried twenty-three years ago to standardize the resistance, but met with a great deal of opposition at that time.

We now have the Monitor and the Westinghouse on which the frames are identical, and we can substitute one for the other, and the frames carry the same ohmic resistance, and have the same carrying capacity.

The General Electric developed a new one, which was out of proportion entirely, and it has made it rather hard in substituting or adding the G. E. resistance to the ribbon type that has already been installed.

I hope that you will meet with success in getting the manufacturers to follow the same scheme, because we have one manufacturer where the switchboard department sends out an entirely different code from the control department code. We have put quite a good deal of installation of that equipment in, and it has confused our field man a great deal.

I do not know whether the idea of carrying your meter wiring under the code, with different colored wires, was brought out or not, as I was not in the room while this paper was being read. We have started to do that so that when our meter man goes to install meters or test meters, and he sees a certain color wire he knows exactly whether that is a C. T. or B. T.

I think this work is certainly to be greatly appreciated. If this can be standardized, I know it will facilitate the installation and will keep our installation costs down.

F. O. Schnure: Thank you, Mr. Farrington. I think it is very important that we carry the color scheme in the installation of meter wiring. It is a little difficult sometimes to get weatherproof cable on which the color or impregnation will not be obliterated. Of course, lead holds its color all right.

W. E. Miller: As I understood Mr. Booth, the intention was to have the drawings made for all controls so you look at them from the front of the board. Is that correct?

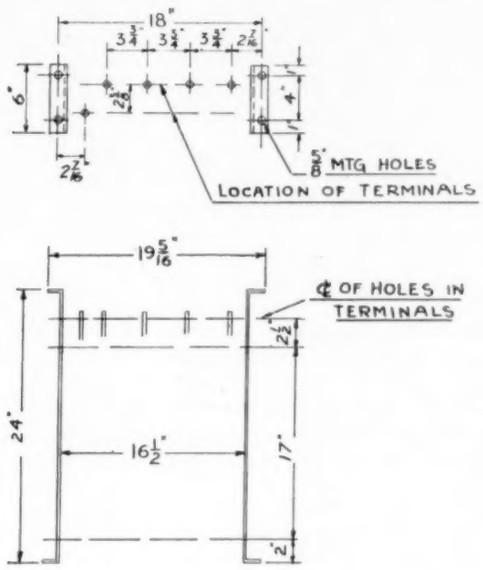
J. J. Booth: No.

W. E. Miller: That is your wiring diagrams.

J. J. Booth: Ninety per cent would be from the rear. A few of those are front-connected.

W. E. Miller: I misunderstood you then. I thought you said the intention was to read your drawings from the front of the board.

I object to any drawings that you look at from the front of the board and then go back of the board



EDGEWOUND MILL TYPE RESISTORS

FRAME Nº	CONT CAP'TY. 300°C	LIST Nº	TOTAL OHMS	UNITS IN PARL	COLOR OF UNITS	COLOR OF END FRAMES	REMARKS
1	120	A14-2601	.35	2-72	RED	RED	
3	70	A14-2603	.78	2-45	WHITE	WHITE	
5	60	A14-2605	1.40	1-72	RED	BLUE	
7	48	A14-2607	2.48	1-55	BLACK	BLACK	
9	15	A14-2609A	18.00	1-15	RED-WHITE	RED-WHITE	
SPC FORM-D	96 60	A14-2927 A	R5-8- 3.00 L1-L4- 72	2-55 1-72	55A - BLACK 72A- RED	YELLOW	37½ HP 230 V PART 'A' OR 'F' BANK ONE 'L' BANK
SPC FORM-D	60 70 120	A14-3129A	A1-X- .828	1-72 2-72 2-45	45 A-WHITE 72A-RED	RED-BLACK	65 HP 230V A-BANK PART 1
SPC FORM-D	120	A14-3130A	X-A8- .351	2-72	RED	BLACK-WHITE	65HP 230 V A-BANK PART 2
SPC FORM-D	60 70	A14-3131A	F1-F4- .934	1-72 2-45	45-WHITE 72-RED	WHITE-YELLOW	65 HP 230V F-BANK PART 1
SPC FORM-D	120	A14-3132-A	F4-F8- 349	2-72	RED	BLUE-YELLOW	65HP 230V F-BANK PART 2

FIG. 1.

to look at your wiring. It confuses you a lot. I think it would be much better if you would adopt the scheme of having the prints made so you look at your wiring according to the way you hold your print, right in the back of the board.

I also think that in marking the contactors and relays on these controls, they should be marked on both back and front. I don't know whether that is the intention or not. I know we sent in a report, and there has been a good deal of discussion on it. I feel if both sides of the boards were marked, it would help the motor inspector to find his trouble. He could do so a lot quicker than he can with the present markings. Everybody seems to have their own code and it is pretty hard for these fellows down in the mill to follow them, especially when you hand them a G. E. board one day and a Westinghouse or an E. C. & M. on the next installation that he goes to work on.

We adopted a standard resistance bank a good many years ago. We were really forced to adopt it on account of some changes in the resistors that we were buying. They became obsolete. The mounting of the resistors really cost the plant more than the resistors. We adopted this a good many years ago, and it has been working out very well. We still stay with the cast iron resistor, but we build our own. We make our own end frames and make our own banks, which are standard.

F. W. Cramer: Our Association has been interested in this movement for a great many years, but the past year I think is the first year in which we have made any great strides.

I don't believe the manufacturer appreciates what the fellow in the mill is up against. Most of our large plants aren't standardized on any particular control, especially on the large orders. He is likely to have three or four kinds of control. I could never see any necessity for so many different ways of making a wiring diagram. The functions are practically identical, no matter who makes the control, and it has always seemed reasonable that we could ask the various manufacturers to get together and in the first place have a uniform system of symbols for the control.

I know the N.E.M.A. have done that on a lot of work, on wiring diagrams, but in the mill control, for some reason or other, it has been neglected.

Mr. Miller emphasized a point in which we were very much interested last year; that is, having something on the front of the board to tell you what the contactors are to jibe up with the diagram, which is made from the rear of the board. We have lettered a good many of those things ourselves.

There is another thing Mr. Booth mentioned that I think is quite important. That is showing a defiite location for your terminal board and your mains and then sticking to it. I don't know of anything that riles you more when you are trying to put in a neat job and have your conduit all ready, and the boards come in just the opposite from your pipe, and you have to throw your control leads clear across the board or your mains. A thing like that could be easily prevented.

He brought up another point. On a particular order I think there were about 150 control boards. The resistance was sent in on a job lot. One each resistance print it told you how many boxes of a definite size to use. We didn't know until we got to the end of the job whether we were right or wrong, and it turned out that we were wrong.

I think it would have been very easy for the manufacturer to have labeled each box of resistance just with the information as to what panel it went for, and we could have checked it up as we went along. As it was, we have several hundred boxes of resistance, and when we got to the end we had a few of the wrong kind left.

Mr. Miller also brought up the matter of dimensions on resistance boxes, which is something that the manufacturers have not been able to understand. The old cast grid resistance, I think was the standard with almost everybody. It had a definite dimension. When they were installed on cranes where room was rather scarce, they just fit.

When the new resistance came along, about half as large again as the old cast grid was, we were all up against it. I think it was that era that drove most of us to buying the grids and making our own boxes. I also think that was wrong, because we are not manufacturers of that type of equipment. But as Mr. Miller brought out, it cost a lot more to change our mounting in the resistance boxes than the boxes were worth.

In conclusion, I would like to ask for some information. Mr. Egan mentioned his resistance boxes with a carrying capacity of 300 deg. C. I was wondering if resistance boxes among the manufacturers have been standardized; that is, if we got a 50 ampere carrying capacity, I would like to ask what that would be based on. I was wondering if the N.E.M.A., or any other manufacturers' association has a definite standard among themselves on the rating of resistance boxes.

R. G. Widdows: On the point Mr. Cramer brought out where the mill receives shipments from the controller manufacturer consisting of a large number of boxes containing resistance sections, master controller, magnetic boards, our practice has been, in the last year or two, to box up the complete controller equipment for one motor all in one box. This box would contain the switchboard, master controller, resistance, limit switches (if used) so that there is no mix-up in applying the proper units to the drive for which they are intended. We can't always do this if the size is very large but this is done wherever possible.

I believe this does away with your difficulty in getting the equipment mixed up and no knowing where it belongs.

F. O. Schnure: In our plant, we are following a system of standard resistance banks similar to the schemes outlined, although we are making every effort to provide the control with the proper resistance at the minimum cost.

We are now erecting a mill that was moved from one of our other plants and in order to use all the different kinds and shapes of resistance units that came with this old mill we are installing it so that when a box burns out we can replace it with one of our modern standard boxes.

F. D. Egan: There is one point that I don't think has been brought out this morning. In building a large mill installation, you experience a condition where there is a certain amount of switch-

board work and a certain amount of auxiliary control work. It is very convenient if you can mount your control apparatus adjacent to the switchboard.

Having that in mind, all our controls in Lackawanna were built 90 inches high 32 and 40 inches in width which enabled us to mount control apparatus adjacent to the switchboards and not effect the structure supporting both.

When we have a mill coming along that would possibly have 75 to 100 auxiliary controllers, when the mill is first laid out and the design of the buildings is submitted to the structural department, we go over the drawings and locate approximately the center of distribution of the various control room numbering from 5 to 7, and when the structural steel is ordered, all supports surmounting the panels and the controllers, as well as the resistance comes forward with the structure itself and is erected with the building, this enables us to start the conduit work immediately.

The control house is then erected having all the holes punched for mounting the panels, resistance banks and even underneath the structure there are holes punched for assembling a complete set of resistance wires all ready made up.

From one control house to the other, the mounting of the resistance wires is exactly duplicated, this enables us to build up the resistance wire combinations in advance much cheaper than doing this work individually.

While this discussion is a little foreign to the subject of nomenclature on control diagrams yet it is part of the problem of drawings for controllers when the problem is completed.

L. A. Watson: Your discussion on resistors and terminal markings has been very interesting to me, as I am a member of the two committees of the Industrial Control Section of the National Electrical Manufacturers Association. I can advise you that the Committee on Resistors has done a great deal of Work on standard rating and classification and is now working on applications of resistors on steel mill control. I will carry to this Committee your remarks on standard banks.

The Committee on Wiring Diagrams and Symbols had their first meeting at Hot Springs in May of this year and very little has been done so far.

About all I can say to the steel men is that the Industrial Control Section of N. E. M. A. is working along the lines of standardizations of electrical control, which will be of great benefit to the iron and steel industry.

R. G. Widdows: I am sorry that Mr. D. C. Wright, our Chief Engineer, isn't here. I am not in the Engineering Department so can not officially state this position, but I am quite sure that the E. C. & M. Company will work heartily with this Committee and with the N.E.M.A. Committee to work out the standardization program. I am sure that when it is finally worked out it will meet all the requirements of the Iron and Steel Electrical Engineers.

Possibly Mr. H. L. Wilcox, who is present and is a member of our Engineering Department, may have something to say on this subject.

H. L. Wilcox: I have noted a few things which have been constant bugbears to the engineers who are laying out control wiring and designing resistance and so forth.

Considering the starting resistor from the standpoint of price and economy, it is best to design each resistor for its particular application, and as several sizes of grids are available it is most economical to taper the grids in the sections and use standard sizes of sections.

Occasionally a customer requests that the sections be made to include only one size of grids and that only one size of section be used in all resistor banks. This, of course, can be done but in most cases at a sacrifice of economy.

Mr. Egan mentioned using standard boxes. I would like to ask him if it is customary to use the same capacity grid throughout the complete filling, or if you would use, for instance, a filling that would consist of a red box, a white box, and a black box, and so forth, assuming the boxes are all of the same dimensions in inches but, of course, of different capacities.

F. D. Egan: In making up the control unit, we utilize any grouping of the boxes required, sometimes in series and sometimes in parallel, for the mill inspector, if he loses a box of resistance, simply replaces it by color. But in one unit it will possibly taper as the resistance in current value is varied.

H. L. Wilcox: Do I understand the boxes for one complete controller would be all white boxes?

F. D. Egan: No, we might use various numbers.

H. L. Wilcox: One other feature with regard to resistance boxes is the actual dimensions. It would be possible to make all boxes the same size, but obviously the boxes would be only a quarter filled or half filled, depending on the number of grids necessary for a starter. Assume that one 48-grid bank would handle a 50 horsepower motor. Then if you were designing resistance starter for 10 horsepower motor, it wouldn't be good economy to use the full 48-grids. You might put ten or twelve in the bank and use spacers on the frame which would be the same size, but I am sure we would have just as many comments on our ungainly resistance bank. That is a question for some discussion.

Regarding the wiring of boards, there has been some mention of rear-view and front-view diagrams. It has been our practice to show the rear view of all the boards where there is considerable wiring and when the board will stand up where the operator can get behind for making connections.

I think it is a good plan to have some indication on the board as to the designation of contactors. We use "M" for the main contactor, "R" for reverse, and "F" for forward and resistance contactors are R1, R2, R3, R4, so the operators learn to call the contactors by name.

For certain units that are usually wall-mounted, where it is impossible for the operator to get behind them, and for units usually front-connected, I see no reason for having rear-view diagrams. I have occasionally checked up on the drawing department, when they have forgotten this and have shown rear-view diagrams of something you couldn't possibly get behind. Sometimes the little panel that goes in a wall-mounted starter is wired up on the back, and

it is perfectly all right for the manufacturers to show a little rear-view diagram for their own shop to use, but the diagram that goes to the customer I think, should be a front view, if the customer can't possibly get behind it.

I think the colored wiring has certain advantages and certain disadvantages. When you get out in the field you are often required to change the wiring; I don't mean through misdesign in the factory, but just through something that comes up, where they want to change the application. You have all seen conditions like that. It is impossible to get the kind of wire that was used before. I think the use of good standard colored wires would be all right.

Boards that involve both A.C. and D.C. circuits, I believe should be wired in two different colors of wire, for instance, white and black, or some easily procurable wire, because in testing apparatus, it is common practice to take a test line that is connected to a 230-volt system in a series of resistance and touch it here and there. If you get into the A.C. circuit with the D.C. test line or vice versa, there is often damage done to small instruments, by using the wrong kind of "juice."

We have had numerous requests for symbols, or a whole set of numbers to represent a line of relays. I have seen figures compiled showing the numbers that might be used for various apparatus and I think it runs up into the hundreds. The whole trouble with that system is that over here a relay may be used for low voltage. Over there, the identical relay is used to control contactors. In some other place it is used for something else. It seems to me that it brings in unnecessary numbers and confusion. A board may include relays of four different types which perform a dozen or more different functions thereby requiring as many designation numbers.

Another thing worthy of mention is the lettering or numbering of diagrams. I too took my early training with the Westinghouse Company, and in drawing complicated diagrams, involving a wealth of interlocking, we simply drew the diagrams, and then started at one side with 1, 2, and 3, and every place a particular wire went, that terminal had the same number. As soon as we finished that wire, we took the next. Just to show what numbers we used, we put them down the side of the diagram. If a wire was rubbed out or eliminated later, that number was crossed off and wasn't used again. I think that is a fine way.

There is another point that is sometimes confusing and that is where manufacturers have specific pieces of control, such as push buttons, limit switches and small starters all connected into an interlocked system. For instance, a push button has a sort of power terminal. It has another terminal which normally forms the maintaining or holding circuit. It has another that makes the circuit through the coil. Our company has been in the habit of calling those P. H and S. Definite small starters will have the power terminals marked L-1 and L-2, and the three control terminals P, H and S. Frequently two pieces of apparatus will be connected together and each apparatus will have a terminal marked P or a terminal marked H or S, but it is impossible to connect similarly marked terminals together because they don't go together. You have to throw out the whole system of letters and start again with a system of numbers.

The push buttons, for instance, come in with the letters stamped right in the porcelain. When we make up a control diagram involving push buttons with other standard pieces of apparatus, are we to forget all the letters and simply number it throughout? If we do number it throughout, and forget these letter markings, and an operator picks up a button with P. H. and S on it, and looks all over diagram for the corresponding letters.

I personally favor the use of numbers—simply numbering a complete diagram, irrespective of what anybody has been used to calling certain terminals. I have heard numerous operators say, however, that they are familiar with push buttons marks P. H and S, and want to see them that way every time.

I think that constitutes the questions that bother me in my work.

J. J. Booth: Mr. Miller has raised the question about the front and rear, and Mr. Wilcox has also elaborated at some length on that point.

At the two meetings which I was fortunate enough to attend, Mr. Miller, it was very definitely pointed out that all wiring diagrams—at least 90 to 95 per cent of them—should be shown looking at the rear of the board.

I might say that we got into what you have mentioned and what Mr. Wilcox has mentioned on the smaller panels, which are front-connected, here in our previous meeting at Cleveland. That is where that particular point was raised and we modified our suggestion a little, that we take in the front connection. Ninety per cent of them, however, would be shown from the rear.

As to the question of marking both front and rear panel, it seemed to be the consensus of opinion that both sides should be marked.

W. E. Miller: I might add that I believe competition is just as keen in the control business as it is in the steel business and the control builders have to design resistors as close to the line as possible in order to keep the control price down. I have found in the past in ordering controls and omitting the resistors so that I could use our standard box, it paid me to be more liberal with the carrying capacity of the resistors than the control builders specified. I believe if the control designers could get into the mills and see the results of designing resistors so close to the line they would have a little different idea of what they could get away with. The price question might not look so big.

H. A. Winne: In the first place I want to express my hearty sympathy with the general aims of Mr. Booth's Committee. I see no reason why it should not be possible to bring about the use of similar symbols and diagrams by all manufacturers, and, in fact, committees of the National Electric Manufacturers' Association I believe are now working with this end in view. I think Mr. Booth's committee can accomplish a great deal for our Association by working very closely with the committee of the N.E.M.A.

As for accelerating resistors used with auxiliary control panels, probably most of you know that for a number of years we, in the General Electric Com-

pany, have used what we call "Unit Boxes" whereby we have only six different boxes for control ranging from 30 to 150 H. P. Each box has only one size of grid in it, all grids are connected in series, and each box has the same number of terminals. We feel we have gone a long way towards making commercially available a resistor system which has the desirable features mentioned by Mr. Egan regarding the scheme he uses.

I think you will find the manufacturers are ready to make whatever you men feel is economically justified, because of course, that in the last analysis has to be the determining factor as to what we shall supply.

As far as the question of diagrams is concerned, we are working very hard on the problem of simplifying our elementary diagrams in order to make them easily readable. For some time we have been making our diagrams so that the various devices occur along the length of the diagram in order of their operation. That means that it is not at all easy to tie together on this diagram all the interlocks, for example, with the main contact in the operating coil of the contactor, other than by numbers. An auxiliary contact may be in the circuit of a coil which operates some time later than the main contact. Maybe there will be several lines along the length of the diagram between these two contacts. It is not very easy to show that they are both on the same device. However, we are working on this problem and expect to be able to solve it.

Again I want to say that we are in sympathy with the aims of the committee, and will do all we can to assist in standardization.

N. L. Mortensen: In general we are in sympathy with the work of standardization in order to bring about greater uniformity and similarity in control diagrams, and we are willing to do our share in making changes in our present standard in order to accomplish this.

I presume that it is more or less natural that the different manufacturers, independently, should not have arrived at the same results as to symbols, marking, and the general making up of the diagram, in that they utilize different methods and different principles in their designs and different types of control systems. I can, however, see no reason why it should not be possible to standardize on these markings, symbols, and nomenclatures for different contactors and relays used on the diagrams. We have all, no doubt, made changes from time to time in our method of making diagrams. We at one time used letters for marking the control circuits, but have now changed to numbers because they simplify the diagrams and make the wiring easier to follow, and we are today using numbers practically throughout for marking the control wiring.

On the question of resistance standardization which Mr. Egan spoke about, we have, like most manufacturers, a certain number of standard boxes and it has been our experience that for certain plants using certain sizes of motors, it is generally possible to work out resistance layouts, with a number of boxes that is economical, and still not use too many different boxes.

Discussion

*Research Covering Alternating Current Arc Welding***

By GROVER A. HUGHES* and R. C. McBRIDE†

Discussed by

W. H. Burr, Electrical Superintendent, Lukens Steel Company, Coatesville, Pa.

G. A. Hughes, Electrical Engineer, Truscon Steel Company, Youngstown, Ohio.

James Farrington, Electrical Superintendent, Wheeling Steel Corporation, Steubenville, Ohio.

S. N. Roberts, Electrical & Mechanical Superintendent, Atlantic Steel Company, Atlanta, Ga.

H. A. Winne, Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

J. S. Degarmo, John A. Roeblings Sons Company, Cleveland, Ohio.

N. L. Mortensen, Chief Engineer, Cutler-Hammer, Inc., Milwaukee, Wis.

W. H. Burr: There is one question I would like to ask. Mr. Hughes brought out that with the coated electrode 28 per cent more electrode was required for welding his specimen than was required for the bare electrode. That is with the A.C. outfit.

I would like to ask if he has made tests which would indicate the same condition holds true with the D.C. welder, or whether with the D.C. welder the amount of bare rod and the amount of coated rod are in the same proportion.

I also want to thank Mr. Hughes and Mr. McBride at this time for the very timely paper. I think most of us in the welding game got the notion in our heads the A.C. welder was a thing of the past. The report which he has submitted this morning gives us something to refer to, gives us something to study, and has really opened up something that I believe most of the fellows in the welding game have overlooked.

With the one question, that is all I have to offer.

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**Presented at Twenty-Seventh Annual Convention at Cleveland, Ohio, June, 1931. Paper appeared June, 1931, issue of Iron and Steel Engineer.

G. A. Hughes: This was one of the Electrodes of a manufacturer who stressed very strongly his particular type of coating—was the only coated electrode that we used that had that peculiar characteristic, of using so much more electrode. Five coated electrodes of different manufacturers were used, but this one gave us the greatest tensile strength. The coating is peculiar in that it required 28 per cent more Electrode. In other words it acted like a shot gun, so to speak, and little globules of metal were thrown all around.

Does that answer the question?

W. H. Burr: Not exactly. I asked if you had made similar comparison with the different coated rods on the D.C. Is there any difference?

G. A. Hughes: With the D.C. this Electrode worked ideally.

W. H. Burr: That is the answer.

James Farrington: I would like to ask if there were any experiments with any other frequency than 60.

G. A. Hughes: The tests in this paper were made with 60 cycle. We have made experiments in our Canadian plant on 25 cycles with A.C. welders, and the results were satisfactory. We then did some experimental work with 180 cycles. That wasn't quite so good. The 60 cycles seems to be about the maximum with the breaking point as far as your welding current is concerned.

S. N. Roberts: You said you wouldn't weld cast iron with the alternating current arc. Didn't you mean also that you wouldn't weld it with the direct current?

G. A. Hughes: I wouldn't weld cast iron at all, either with alternating current or direct current.

S. N. Roberts: That is what I understood. I wanted to get it correct.

H. A. Winne: Mr. Hughes makes the statement that they now have the alternating current arc welding working with the same voltage as with the direct current, equally as well there with the coated electrodes. I would like to ask if he is really welding satisfactorily with the bare electrodes on open circuit.

G. A. Hughes: There are three manufacturers making alternating current welders today and all three manufacturer's equipment are satisfactory.

H. A. Winne: That then is making use of the auxiliary high frequency. What I had reference to was just an open circuit, in a voltage of 60 volts with no auxiliary means. Our experience has shown that is not practical.

J. S. Degarmo: There was a question, Mr. Hughes, as to the 28 per cent, you stated that you had tested five different coated rods, and one of them gave 28 per cent. Did the other four also give a higher per cent?

G. A. Hughes: No, they were less. They ran about 3 per cent.

J. S. Degarmo: Three per cent more than bare?

G. A. Hughes: Yes, but we took this one because it gave us so much greater tensile strength.

N. L. Mortensen: Since the content has been put so forcibly, I thought I would tell you of a very recent experience we had. There was a cast iron piece that had to be so thin that it was impossible to use steel. That cast iron piece was welded to a steel band, and when they first tried it, it would break right off in the weld. But upon using the coated electrode, and as I recall it, reversing polarity, they got very satisfactory results. We have made a great many of those pieces since then.

I thoroughly agree as to the difficulties of welding cast iron. But when we are manufacturing commercially a piece that has to be fastened to a steel piece, it does not have to withstand any greater stress than might be introduced by accidentally hitting it. If it is a piece that would be hit in handling, we can test it by the blow of a light hammer. The inspector gives it a sharp rap with an ordinary hammer on either side. At first every one we hit that way broke off. But with the coated rod, and I believe the reverse polarity, we get apparently entirely satisfactory results.

G. A. Hughes: To start with, your cast iron is high in sulphur and your impurities are great. When you commence to add what you can expect in the way of purities from your welder, you have a grade of cast iron that is usually poorer than the original grade, unless you have a piece that is large enough so you can preheat and then put in studs and weld through your studs.

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Discussion

Conductors of Heavy Alternating Currents‡

By D. I. BOHN* and H. W. PAPST†

Discussion Presented by

J. J. Booth, Electrical Superintendent, National Tube Company, Gary, Ind.

F. W. Cramer, Chief Electrical Engineer, Republic Steel Corporation, Youngstown, Ohio.

R. W. Davis, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

O. C. Callow, Freyn Engineering Company, Chicago, Ill.

A. J. Whitcomb, Assistant Electrical Engineer, Freyn Engineering Company, Chicago, Ill.

W. E. Miller, Electrical Superintendent, Bethlehem Steel Company, Johnstown, Pa.

W. H. Burr, Electrical Superintendent, Lukens Steel Company, Coatesville, Pa.

C. O. Franklin, Electrical Department, Carnegie Steel Company, Homestead Works, Munhall, Pa.

D. I. Bohn, Electrical Engineer, Aluminum Company of America, Pittsburgh, Pa.

F. R. Dallye, Aluminum Company of America, Pittsburgh, Pa.

P. T. Gross, Aluminum Company of America, Cleveland, Ohio.

J. J. Booth: Now, gentlemen, we will have discussion on this paper somewhat similar to the discussion previously given, with the exception that Mr. Bohn and Mr. Papst will divide the discussion as they see fit; that is, the answers to whatever questions you may ask. The meeting is now open for discussion or remarks.

F. W. Cramer: I would like to ask Mr. Bohn a question. He did not mention whether any particular pains were taken in making the joints. I know all of us had some fear on this particular point. I was wondering if there were any developments lately.

R. W. Davis: The only place that I know that an aluminum bus has been used is in the ninty-six inch plate mill at the South Works. It has given very excellent work.

O. C. Callow: I have nothing to say at this time. Mr. Cramer's question is interesting, however, and I would be glad to hear the answer to it.

J. Farrington: I didn't get a chance to read the paper, but there is a question I would like to ask. Are they using the welding method in building a bus in sections, and then welding them to get away from poor joints?

F. O. Schnure: One of the two questions I had in mind was asked by Mr. Cramer; the other is the idea of using aluminum for a conductor.

A. J. Whitcomb I have heard some operators say that due to expansion it is necessary to make some special provisions when using aluminum bus bars. If it is necessary to provide special arrangements for aluminum bus bars, what are they?

A Member: Have you anything on the relative differences of the effect of short circuits on aluminum versus copper? I would like to amplify that a bit. I took an extensive trip to the Pacific Coast last year. I was surprised at the number of people who asked me if that bus didn't go up in smoke on a heavy short. When a copper bus goes you scrape up the copper, but when an aluminum bus goes up what do you do?

W. E. Miller: I think Mr. Bohn is prepared to undertake almost anything on this question of aluminum bus. I would like to ask him how he handles the Public Service Commission on the ice loading of cables on long span transmission lines.

When we were figuring on some long spans on transmission lines it was at first decided to use steel reinforced aluminum. The size of this type of conductor was much larger than copper conductors for the same carrying capacity. The larger conductor size increased the ice loading on the towers and increased the size of the tower foundations and towers to such an extent that when the Public Service Commission's regulations on this point were met it was much more economical to use copper conductors which permitted the smaller towers and foundations.

W. H. Burr: Is there any disadvantage in connecting your copper from your circuits to the main bus made of aluminum. What bothers most of us is the joint. I was wondering if there was any difficulty experienced, or anything to fear in making a short span bus to an aluminum conductor.

C. O. Franklin: I would like to ask what is the largest size channel that has been used in this bus construction. Also I noticed that the cross-section of the splice bar didn't seem to be of the same cross-section as the channel itself. I was wondering if that would not cause a high resistance joint?

D. I. Bohn: This discussion has developed a little away from the main theme of the paper in considering the materials used. However, since it has gotten into that general trend I will endeavor to answer the questions to the best of my ability.

Mr. Cramer asked about the resistance of joints. When I came with the Aluminum Company I didn't know whether they grew aluminum on trees or where they got the stuff, but the plant with which I went had practically all of the bus work in aluminum. We just took it for granted and handled our hundred thousand kilowatts and didn't worry about it. That has been our normal experience with it.

I have been interested in a great many thoughts in regard to joint resistance and I have often won-

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‡Presented at A. I. & S. E. E. Convention, Cleveland, Ohio, June 17, 1931. Paper appeared June 1931 issue.

*Electrical Engineer, Aluminum Co. of America, Pittsburgh, Pa.

†Engineering Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

dered from where some of the ideas have come. Personally, I haven't bothered with any of the joints, aluminum or copper. If you don't have pressure it makes no difference whether it is aluminum or copper. If you have sufficient pressure there can be no oxidation. On a thick bus joint a spring washer can be applied, which I believe is becoming more extensively used. We fooled with a great number of them. That is a great item in maintaining pressure.

This will overlap another question asked regarding applying copper to aluminum, and aluminum to aluminum. Taken over a period of ten years' operation we found that they were in the same shape as when they were installed.

We do recommend the use of a petroleum product on the contact surfaces. The one we use and like the most is called "No-Ox-Id." The only difference between vaseline and "No-Ox-Id" is that the latter will stay there; it won't run in hot weather and it won't wash off in rain. "No-Ox-Id," or something of that sort, is, of course, a help in preventing water from getting into the joints, but as far as I have been able to see from experience the joint proposition is simply a matter of making what is a good joint regardless of the metal, and then you don't worry about it.

I would be glad to answer any detailed questions on that if I haven't made myself clear.

A Member: What kind of bolts do you use for those joints?

D. I. Bohn: Welding is, of course, quite easy. A trained operator makes a beautiful job, and if a person wishes, the entire job can be so done. It is not necessary, however. You simply bolt your job up, putting it together, and seeing that you have a design that will give you high unit pressures rather than a high total pressure.

With respect to expansion, aluminum has an expansion co-efficient of some 30 per cent more than copper. As I mentioned before, a flat bar job will be installed with a number of supports, and then expansion joints will be provided as the appearance indicates. One fellow will install frequent expansion joints and another will go away and forget to do it. Theoretically, there should be a sufficient number of expansion joints so that the bars will be kept absolutely straight. With the channel design, if it is necessary to rigidly grip it at more than one point, flexible joints are installed made of 10 or 15 mil sheets of aluminum.

With respect to short circuits I have never had occasion to see aluminum disappear and have often been there right after the short.

F. R. Dallye: About a year ago we ran some experiments on flashovers with tubular buses, at the request of one of the public utilities, just to see what would happen when an arc was formed between a copper tube and an aluminum tube of equal carrying capacity. I might say that the results were rather surprising, and similar experiences have confirmed these tests, which showed that the arc on the aluminum apparently has no tendency to hold at one spot.

I might also say that the results of that test on tubing showed that the aluminum would have surface marks, whereas the copper arc had more of a tendency to hang on at one spot and burn through. The damage of that particular test showed greater on the copper than the aluminum.

D. I. Bohn: Mr. Miller asked about ice loading transmission lines. Mr. Dallye, would you mind continuing?

F. R. Dallye: I will politely pass the buck, because my work has been more or less on buses rather than on cables. I will ask Mr. Gross if he will do a little dirty work.

P. T. Gross: The troubles Mr. Miller spoke about have been in connection with an all-aluminum cable rather than the type of cable that is now commonly used, which is an aluminum cable steel reinforced. The results of ice and wind will be greater on aluminum cables than on copper cables, but the strength of an aluminum cable steel reinforced is much greater than copper, making it possible to go to longer spans with a construction cost that is much lower than copper construction would cost you. It is true, however, if you are designing a long dead ended span with steel reinforced aluminum your towers would have to be a little stronger to take the extra tension in the cables due to ice and wind loads.

W. E. Miller: We found out in our case that the difference in cost between the towers for aluminum conductors and those for copper conductors was such as to more than compensate for the difference between the cost of the conductors.

P. T. Gross: In what State was that?

W. E. Miller: It was in the State of Pennsylvania.

P. T. Gross: I do not know much about their requirements. In most cases the State holds you down to a factor of safety of two to one. You cannot load your conductor to more than one-half of its ultimate strength, when it is loaded to its maximum; that in turn will limit your span length or tower height. It is not a very favorable situation in the State of Pennsylvania, I will grant you that.

D. I. Bohn: There was one thing mentioned I didn't emphasize. We took a couple of channels placed normally, ran them at 29 deg. rise on a certain load, rearranged them back to back, and with the same load they ran at a 46.5 deg. rise. That was a small sized channel, and the effect will be greater on larger channels.

In regard to connecting copper to aluminum, I am sorry but I will also have to refer to particular experiences of jobs that I know about. We have, of course, a great number of D.C. circuit breakers, and in all cases the terminals are copper. These are tied right in with the aluminum bus as though they were copper to copper or aluminum to aluminum. On D.C. breakers we simply bolt the aluminum bars directly into the breaker studs, the only difference in some cases being that we have the studs made longer.

As far as the copper to aluminum joint goes, it is in exactly the same class as any other. If you put it together and apply sufficient pressure you can go to sleep and not worry about it. That has been our experience and the experience of a great many others. The largest sized channel that we make is 10 inches. In general, I wouldn't expect this channel construction to extend much above 8000

or 10,000 amperes A.C. Any current above that is at low voltage. We expect that 2000 to 8000 amperes A.C. would ordinarily cover the applications of this channel construction. The 8-inch is the largest size we tested and the 4-inch the smallest. The 3-inch might have some applications.

The ventilation through the center of the channel construction is apparently very good. Of course, the only way we can tell is through tests, but, considering the cooling through the middle of the channel and the convection action, the inner surface is nearly as effective as the outside surface.

With respect to the question of splice plates, may I see slide No. 7, please? In general, the cross-section of a splice plate is made the same as the cross-section of a channel. You can see, dotted in there, that the splice plate is very considerably thicker than the web of the channel, and the sections are, very roughly, the same as this entire channel.

F. W. Cramer: Before closing, Mr. Bohn, I would like to relate some past experiences. When it comes to expansion joints, figuring from a straight expansion of metals, you will find that it is figured on dead air, which condition you never have in putting up bus bar. We had a job about 500 feet long and a good many dollars were spent for expansion joints.

On investigating we found that the tunnel had a constant draft through it. With the little investigating we did at that time it indicated that even a draft, say, of a mile an hour or a few hundred feet it did a great deal toward cooling off that bus; so the temperature rises were practically nothing. As long as you have some moving air going along the bus you won't have any trouble with it.

D. I. Bohn: I don't believe the expansion joints require much figuring anyway. With the flat bar it is pretty hard in the first place because, assuming all supports rigidly fixed to the bars, you would need a joint between each support. You don't do that, however; you simply go along a little ways and put an expansion joint in, and if a support gives, you put another one in. If you get extreme heat the bars will just bow out.

I remember one case where we had a furnace that was running at 36 cycles. It was just a plain flat bar job, and no bad skin effects were encountered. However, for a period of a couple of months we had to operate at 60 cycles. We knew we would have plenty of trouble with power factor, but we dug up old rotaries for condensers. These buses are made of 10-inch bars. There was probably 8 or 10 inches between phases, and they were bolted solidly at both ends so that individual bars could not move with respect to each other, but the entire bus could travel. After operating a few hours we found that the middle bars stayed at about the same length as they were in the beginning. The outer ones, however, had swelled way out and made a fine short circuit. Incidentally, the bars were not damaged from the short circuit. All we did was to run a piece of fiber between phases and it ran for the few weeks required.

A Member: Mr. Bohn, I would like to ask if you have ever had any experience on your aluminum bus, whether the bus requires any more clamping in order to hold its position than you would ordinarily put in a copper bus. A copper bus weighs considerably more, for instance, a 40,000 ampere D.C. bus. We had one. Sometime during the night it was all strewn down the tunnel for about 400 or 500 feet, and it was quite badly damaged. I just wondered if it really required more clamping in order to hold this bus in position than you would naturally have with a copper bus, on account of the increased weight.

D. I. Bohn: It is a little hard to tell you, not knowing the particular type of support. Do you mean supported from underneath?

A Member: Yes, the insulating support. It won't stay up there, but no bus will stay in position unless it has some type of clamp, the type that could be of almost any design.

D. I. Bohn: Normally, if you were speaking of 50,000 ampere jobs, most of ours hang from these little Johnny-Balls.

W. H. Burr: One more question. What do you consider the best method of joining together sections of aluminum conductors for overhead service?

P. T. Gross: By making a compression joint with a hydraulic compressor. A cast aluminum sleeve or compression joint is compressed on the two sections of cables with a 100-ton tydraulic press. This type of joint develops 100% efficiency, electrically and mechanically.

OFFICERS OF PITTSBURGH SECTION, A. I. & S. E. E.

1931 — 1932

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Items of Interest

PERSONNEL CHANGES

Harry J. Fisher, formerly with the Reliance Electric and Engineering Company as sales manager, will on November 2nd take over a new position, that of manager of sales with the Aetna-Standard Engineering Company of Youngstown, his headquarters will be in the general offices of the Company in that city.

HARRY J. FISHER

His entire business career has been in the line of selling and sales engineering to the Steel Plants of the United States and Canada.

Upon his graduation from The University of Michigan with the Engineering Class of 1913 and following an apprenticeship of a few years with The Electric Controller and Manufacturing Company, he entered into the selling field with that organization as a sales agent in the Pittsburgh district.

In the year 1917, Mr. Fisher entered the employ of The Reliance Electric and Engineering Company and at that time, in the capacity of manager of the Pittsburgh district, opened the Pittsburgh Sales Office of that Company in which position he continued until 1919 at which time he was transferred to the Cleveland Office and three years later placed in charge of Steel Mill Sales throughout the United States and Canada. It was in this position that he continued up to the present time.

Mr. Fisher has been instrumental in the development of numerous steel plant improvements, one of which is the application of electric motors to wire blocks.

In his 18 years of selling and sales engineering, 14 years of which was with one Company, Mr. Fisher has gained a host of friends in the Steel Industry, who are sure to wish him the best of luck in his new connection. Mr. Fisher has been an associate member of the A. I. & S. E. E. for fourteen years.

F. J. Griffiths has joined The Timken organization at Canton, O. He has been elected director and president of The Timken Steel and Tube Company. M. T. Lothrop, president of The Timken Roller Bearing Company, has been made chairman of the board of The Timken Steel and Tube Company.

Mr. Griffiths comes to the Timken Company with vast experience and a broad understanding of the present problems of the Steel Industry, with which he has been prominently identified for 30 years. Until recently he was associated with the Republic Steel Corporation in the capacity of president of the Republic Research Corporation. Mr. Griffiths began his career in the Steel Industry with The United Steel Company at Canton, and later helped to organize The Central Steel Company in Massillon, O., of which he was president and general manager. When these two companies were merged to form The Central Alloy Steel Company, he was chosen chairman of the board, which office he held until the Central Alloy merger with Republic.

J. Duff Reed, formerly with the Ventilating Equipment Corporation, announces that he is now district representative for the American Air Filter Company, Inc., Louisville, Ky., with offices at 1009 Bessemer Building, Pittsburgh, Pa.

Bailey Meter Company announces the location of sales engineers in two Southern cities. M. J. McWhorter, who formerly made his headquarters at 39 Fairhaven Circle, Atlanta, Ga., is now located at 1708 Euclid avenue, Charlotte, N. C. Mr. McWhorter continues as manager of the Southern territory, and is assisted by J. H. Whittlesey, who has headquarters at 3201 Carlisle road, Birmingham, Ala.

Harry L. Erlicher has been appointed purchasing agent of the General Electric Company, succeeding L. G. Banker, who retired on October 1 after completing 43 years continuous service with the Company.

The industrial sales department of the Westinghouse Electric and Manufacturing Company has been reorganized under the direction of O. F. Stroman, industrial sales manager. The reorganized department is composed of units grouped according to the main classifications of industry.

Bernard Lester and C. B. Stainback have been appointed assistant sales managers.

Under Mr. Lester there has been created five industry divisional classifications with the following in charge: G. E. Stoltz, manager, mining and metal working electrification division; G. D. Bowne, manager, general mill electrification division; J. W. Speer, manager, machinery electrification division; E. B. Bremer, manager of the appliance electrification division, and E. F. Mead, manager, general industrial resale division.

Nine divisions have been created under Mr. Stainback's supervision. They are headed by J. R. Olnhausen, manager, medium A.C. motor section; R. M. Davis, manager, medium D.C. motor section; R. O. Watson, manager, large motor section; D. H. Byerly, manager, small motor section; W. W. Reddie, manager, welding section; T. C. Kelley, manager, industrial heating apparatus; W. G. Balph, manager, safety switch section; W. H. McGillivray, manager, control section, and F. W. Horst, manager, cost section.

J. M. McKibbin, Jr., has been appointed manager of the promotion and advertising section.

WITH THE MANUFACTURERS

Combustion Engineering Corporation, 200 Madison avenue, New York, has recently developed a new type of boiler which provides a logical solution to the problem of insuring adequate circulation and correct steam liberation under the most severe conditions of operation. This boiler is now offered to the steam generating industry.

The Brown Instrument Company has issued their latest Flow Meter Catalog No. 2002, featuring the latest developments in this line of electric flow meters operating on the inductance bridge principle. One of these new developments is the low range manometer. This manometer will be found very satisfactory for measuring the flow of gases, inasmuch as it is exceedingly sensitive, being capable of accurate flow measurement on very low differential pressures. Another new development is the Brown high pressure flow meter manometer, designed for measuring the flow of liquids, vapors or gases that are under pressures up to 5000 pounds per square inch.

Any readers who would like to have a copy of this catalog, write to The Brown Instrument Company, Philadelphia, Pa.

A new oil immersed, explosion proof, auto-transformer type automatic starter for A.C. squirrel cage motors, is announced by Cutler-Hammer, Inc., 259 North Twelfth street, Milwaukee, Wis. Designed to comply with Underwriters' requirements for Class 1, Group D installations, it provides a six-inch head of oil above the contacts and incorporates oil level indicator and outside spout for replenishing the oil without removing the cover. Terminals are located above the level of the oil so that the oil will not cause the rubber insulation to deteriorate and cause short circuiting.

The Reliance Electric and Engineering Company, 1088 Ivanhoe road, Cleveland, O., manufacturers of alternating and direct-current motors, have developed a new line of small D.C. motors to supplement their larger well-known Type T Heavy-duty Motors.

The new motors are built in sizes from ½ h.p., 1750 r.p.m. to 3 h.p., 1750 r.p.m. for constant or adjustable-speed operation.

A feature not usually found in such small motors is the refillable-type commutator. If the copper bars should ever become damaged or badly worn, they may be easily removed and replaced. Another unusual feature for small motors is the provision of two brushes per stud. This betters commutation and keeps these power units running longer and steadier with less attention.

The Trumbull Electric Manufacturing Company of Plainville, Conn., are pleased to announce the addition to their line of the Nofuze Load Center. This Nofuze Load Center, which is for protecting the lighting, water heater or range circuits in the home, can be supplied in from 2 to 8 circuits, flush or surface mounting with either 15, 20, 25, 35 or 50 ampere circuit breakers mounted therein.

This is regularly supplied broken down into box, circuit breakers and front, but can be furnished for a small extra charge completely bussed, assembled and packed as one complete unit.

The Bristol Company, Waterbury, Conn., is offering a new line of Air Operated Recording Controllers, employing a "Free Vane" as the initiator of control, which is a new departure in Air Operated Control.

The Trico Fuse Manufacturing Company of Milwaukee announces a complete line of Insulating and Auto-Transformers of the air-cooled type, ¼ to 50 K.V.A. All sizes are approved by the Underwriters' Laboratories, Inc.

Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has just issued a new bulletin No. 1907, describing "Turbo Blowers and Turbo Compressors" which will be sent to anyone upon request.

They have also issued bulletin No. 3011, describing their "Double Disc Coil Construction and Power Transformers." This bulletin will also be sent upon request.

Crouse-Hinds Company, Syracuse, N. Y., has just issued their bulletin No. 2241, which describes "Flood Lighting." For a copy write Crouse-Hinds Company, Syracuse, N. Y.

The New Departure Manufacturing Company at Bristol, Conn., has just issued a 66-page booklet in connection with "Dimensions and Load Data on the New Departure Ball Bearings."

Write C. B. Beckwith, Advertising Manager, New Departure Manufacturing Company, Bristol Conn., to obtain a copy.

The Autumn issue of "Powerfax" prepared by the Elliott Company at Jeannette, Pa., is an extremely interesting periodical and contains many interesting facts about Power Plants. By writing C. W. Kalbfus, Advertising Manager, Elliott Company, Jeannette, Pa., you may secure a copy.

The Monitor Controller Company at Baltimore, Md., has a very interesting leaflet in the mails on the subject of "Automatic Controllers." Write the Monitor Controller Company at Baltimore, Md., for a copy.

The Weston Electric Instrument Corporation announces the development of the Weston Photronic Cell. Write L. C. Merchant, Publicity Department, Weston Electric Instrument Corporation, Newark, N. J., and they will be glad to tell you about this new Cell.

The Pyle National Company, Chicago, Ill., is distributing their bulletin No. 167 on "Flood Light Tripods, Portable Flood Lights and Flood Light Mounting Brackets." A copy of this bulletin may be obtained by writing the above company.

ASSOCIATION ACTIVITIES

The Birmingham District Section of the Association of Iron & Steel Electrical Engineers will discuss "Roller Bearings" at their October 31 meeting. W. L. Long of Hyatt Roller Bearing Company will present a paper.

"Flexible Couplings for Steel Mills" by Gustave Fast of the Bartlett Hayward Company will be given November 28.

At the Pittsburgh District Section's meeting October 24, a paper covering "The Application of the Photo-Electric Relay in Steel Mills" will be presented by L. F. Worden of the General Electric Company.

At the November meeting of the Pittsburgh Section a paper on "Rolling Mills" will be presented by A. F. Kenyon of the Westinghouse Electric and Manufacturing Company.

In December a paper will be given on "Combination System of Sheet and Tin Mill Rolling."

The January paper in Pittsburgh will be a Symposium covering "Brake Linings."

The Chicago District Section will conduct an Inspection Trip to the South Chicago Plant of the Illinois Steel Company in October.

The Cleveland District Section will start their first meeting of the year off with a paper on "The Uses of Phenolic, Laminated and Molded Materials in the Steel Industry" by H. M. Richardson of the General Electric Company.

COMING MEETINGS

The British Iron & Steel Institute plans an excursion and technical sessions in America, Monday, September 12, to Thursday, September 15, 1932.

The Metallurgical Advisory Board for the Carnegie Institute of Technology and the U. S. Bureau of Mines opened their Fifth Annual Meeting Friday, October 16, 1931.

Progress made on research problems undertaken jointly by Carnegie Institute and the Bureau of Mines was discussed during the morning and afternoon sessions by investigators of both laboratories.

The Third International Conference on Bituminous Coal will be held at the Carnegie Institute of Technology, Pittsburgh, Pa., on November 16-21, 1931.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

Name of Publication: Iron and Steel Engineer, published monthly at Pittsburgh, Pa. (Report of October 1, 1931).
Editor—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Business Manager—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

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President, J. J. Booth, National Tube Co., Gary Ind.
First Vice President, J. D. Donovan, Republic Steel Corp., Massillon, O.
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Known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

JOHN F. KELLY, Editor.

Sworn to and subscribed before me this 26th day of September, 1931.
HENRY W. BALDWIN, Notary Public.
(My commission expires April 18th, 1933).

IRON AND STEEL STATISTICS

Year and month	General operations				Iron and steel		Pig-iron production	Steel ingots		Fabricated structural steel		United States Steel Corporation, unfilled orders end of month	Manganese (ore content), imports	Prices			
	F. R. B. index (adjusted) [1]	Rate of operations, electric energy consumption	Employment adjusted [1]	Pay rolls unadjusted	Exports	Imports		Production	Per cent of capacity	New orders	Shipments			Steel billets, Bessemer (Pittsburgh)	Iron and steel composite	Structural steel beams	Composite finished steel
	Monthly average, 1923–1925=100				Thousands of long tons				Per cent	Thousands of short tons		Thousands of long tons		Dolls. per long ton		Dolls. per 100 pounds	
1929: August	143	150.9	101.4	109.3	243	61	3,756	4,939	93	341	315	3,658	32	35.00	36.57	1.95	2.55
1930:																	
August	92	112.0	83.9	77.5	151	27	2,524	3,061	59	252	262	3,580	8	31.00	33.01	1.65	2.26
September	85	110.3	81.7	75.4	131	30	2,277	2,840	55	156	243	3,424	22	31.00	32.67	1.60	2.24
October	74	126.0	81.3	75.8	132	30	2,165	2,693	50	209	239	3,482	18	31.00	32.31	1.60	2.22
November	65	106.5	80.2	68.9	112	35	1,867	2,212	44	151	195	3,640	10	31.00	31.95	1.60	2.20
December	59	110.2	79.1	66.7	102	24	1,666	1,980	38	153	168	3,944	29	30.60	31.76	1.60	2.19
1931:																	
January	64	103.4	77.5	62.4	93	32	1,714	2,459	43	162	172	4,132	17	30.00	31.70	1.63	2.22
February	73	116.5	75.9	67.5	91	21	1,707	2,502	49	158	166	3,965	10	30.00	31.65	1.65	2.22
March	78	119.4	76.6	70.0	110	31	2,032	2,994	54	184	151	3,995	2	30.00	31.66	1.65	2.23
April	75	108.1	76.5	69.1	101	39	2,020	2,722	49	293	158	3,898	33	30.00	31.61	1.65	2.22
May	72	106.8	74.8	64.9	91	28	1,994	2,505	45	153	148	3,620	21	29.50	31.39	1.65	2.21
June	64	86.6	72.6	57.6	76	29	1,639	2,076	38	177	162	3,479	37	29.00	31.02	1.65	2.19
July	59	83.1	72.1	52.4	84	27	1,463	1,886	34	159	182	3,405	38	29.00	31.05	1.65	2.20
August	51	78.0	70.3	50.6	73	21	1,281	1,719	31	124	169	3,169	67	29.00	31.05	1.60	2.19
Monthly average, January through August:																	
1929	139	156.5	99.5	107.7	263	49	3,648	4,853	95	309	273	4,175	31	34.54	36.63	1.93	2.56
1930	106	129.2	90.3	90.7	189	38	2,928	3,695	72	253	268	4,188	25	32.31	34.25	1.76	2.37
1931	67	100.2	74.5	61.8	90	29	1,731	2,358	43	176	164	3,708	28	29.56	31.39	1.64	2.21

[1] Adjusted for seasonal variation.

Taken from the October 1931 issue "Survey of Current Business."